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COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

INTERNATIONAL CO-OPERATION IN THE PEACEFUL USES OF OUTER SPACE - ACTIVITIES OF MEMBER STATES

Note by the Secretariat

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1. The Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), in paragraphs 4, 5 and 6 of the report on the work of its fourth session (A/AC.105/456, annex II), made a series of recommendations concerning the preparations of reports and studies by the Secretariat and the compilation of information from Member States.

2. The Working Group recommended, in paragraph 4 (c) of its report, that the Committee request all Member States, particularly those with major space or space-related capabilities, to submit an annual national report to the Secretary-General on their space-related activities in which there could be greater international co-operation, with particular emphasis on the needs of the developing countries.

3. The Working Group also recommended, in paragraph 4 (j), that the Outer Space Affairs Division prepare on a regular basis an updated report on the resources and technological capabilities of States in the fields of space activities for the promotion of co-operation in the peaceful uses of outer space, on the basis of information provided by them.

4. The Working Group further recommended, in paragraph 6 (b), that a report be prepared, on the basis of information provided by Member States, dealing with the implementation of the priority recommendations of UNISPACE 82 addressed to Member States, as identified in paragraph 9 of General Assembly resolution 44/46 of 8 December 1989.

5. The report of the Working Group was adopted by the Scientific and Technical Sub-Committee at its twenty-seventh session (A/AC.105/456, para. 21) and the recommendations of the Working Group were endorsed by the Committee on the Peaceful Uses of Outer Space at its thirty-third session 1/ and by the General Assembly in its resolution 45/72 of 11 December 1990, paragraph 10.

6. The Secretary-General subsequently addressed a note verbale dated 14 August 1990 to all Member States, requesting them to communicate to the Secretariat, by 1 October 1990, the information requested in the above-mentioned recommendations.

7. The Secretary-General also drew the attention of Member States to the recommendation of the Committee, as contained in paragraph 139 of its report:

> "The Committee recommended that the Secretariat invite Member States to submit annual reports on their space activities. In addition to information on national and international space programmes, the reports could include information in response to requests from the Working Group of the Whole as well as information on spin-off benefits of space activities and other topics as requested by the Committee and its subsidiary bodies." 2/

8. In accordance with the recommendation of the Committee, the Secretary-General further suggested to Member States that information in response to those requests could be submitted in a single report on national space activities, with an indication of information that responds to specific requests from the Working Group.

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9. The present document was prepared by the Secretariat on the basis of information received from Member States as of 12 December 1990. Information received subsequent to that date will be included in addenda to the present document.

Notes

1/ *Official Records of the General Assembly, Forty-fifth Session, Supplement No. 20* (A/45/20), para. 30.

2/ *Ibid*., para. 139.

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AUSTRIA

[Original: English]

1. LIAISON AND CO-ORDINATION

Austrian Space Agency, Vienna

On 1 January 1987 Austria became a full member of the European Space Agency (ESA). The annual contribution of the Republic of Austria to ESA amounted in 1989 to about 220 million Austrian schillings.

According to the terms of references of the Austrian Space Agency (ASA) the main tasks are as follows:

- To co-ordinate projects in the field of space research and technology in Austria and abroad, as well as within the framework of international agreements and organizations;
- To establish and maintain contacts with foreign institutions engaged in space research and technology;
- To advise the Austrian Government on matters concerning space research and technology in line with Austrian interests and requirements and taking into account international developments in this area;
- To process and distribute information and data on space research and technology to all interested parties in Austria, as well as to publish relevant documents;
- To promote the training of specialists in the field of space research and technology, in co-operation with university institutes and research organizations within Austria and abroad;
- To carry out public relations activities, in particular the organization of relevant meetings;
- To promote the awarding of contracts to industrial and scientific institutions in Austria;
- To act as secretariat for the Advisory Committee on Space Research and Technology of the Austrian Federal Government.

All these activities have to be carried out outside ASA-owned research facilities. It is ASA's task to support and promote the activities of existing scientific and industrial institutions in the field of space research and technology.

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Co-ordination of activities related to ESA programmes

In addition to the involvement in the mandatory programme (general activities and science programme), Austria participated in the following optional programmes:

- Earth observation programme:

    European Remote Sensing Satellite ERS-1
    Laser Synchronization from Stationary Orbit (LASSO)

- Telecommunications:

    Telecommunications satellite Olympus
    Advanced systems and technology Programmes (ASTP)
    Payload and spacecraft development and experimentation programmes (PSDE)
    Data relay satellite preparatory programme (DRPP)

- Space stations and platforms:

    Preparatory programme for the Columbus Space Station

- Space transportation systems:

    Preparatory programme for Hermes
    Hermes development programme
    Ariane-5 development programme

It is planned to participate in future in the new telecommunciations programme DRTM and in the new Earth observation programmes of ERS-2 such as the Polar Orbiting Platform and the extension of the Earth Observation Preparatory Programme. A participation in the Columbus Space Station Programme is not envisaged.

Staff members of ASA are attending the meetings of the relevant programme boards to represent the Austrian interest in these activities.

A general evaluation of Austria's collaboration in ESA activities shows satisfactory results. The industrial return coefficient calculated by ESA for all countries, showing the geographical distributions of contracts awarded, amounts of 0.83 for Austria as of March 1889. So far, the financial return to scientific research institutions amounted to 20 per cent of the overall return. The other portion of 80 per cent went to Austrian industrial companies.

Remote-sensing activities

An ASA working group on remote sensing has continued to operate with the tasks of information exchange and promotion of remote-sensing activities in Austria. ASA acts as the national point of contact for the distribution of LANDSAT data in close co-operation with the Earthnet programme of ESA and Eurimage, and possesses a data

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file of all LANDSAT images taken over Austrian territory. ASA is a member of the European Association of Remote Sensing Laboratories (EARSeL) and has acted since June 1989 as national representative.

Co-ordination of bilateral space activities

Basic agreements without any financial obligations were concluded with the National Aeronautics and Space Administration (NASA) of the United States of America and with the space authorities of France, the Federal Republic of Germany,* Norway, Sweden and Switzerland and serve as a basis for co-operation. Joint space projects can be based on these agreements.

Co-operation with the Union of Soviet Socialist Republics (Intercosmos) is based on an agreement between the Soviet Academy of Sciences and the Austrian Academy of Sciences.

United Nations

ASA is actively participating in the work of the United Nations Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Sub-Committee. The main topics on the agenda are the applications of remote sensing from space for the needs of developing countries, the future utilization of the geostationary orbit and the safe use of nuclear power sources in space.

International Astronautical Federation

ASA is a voting member of the International Astronautical Federation (IAF). The Managing Director of ASA is a member of the IAF Bureau, serving as Past-President until October 1990.

Summer schools, workshops and seminars on space research

ASA organized international summer schools in Alpbach, Tyrol, in co-operation with Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR) (Germany), the Centre National d'Etudes Spaciales (CNES) (France), the Schweizerische Akademie für Naturwissenschaften (SANW) (Switzerland) and ESA:

- From 29 July to 7 August 1987, on "Space Science and Fundamental Physics".

- From 27 July to 4 August 1989, on "Remote Sensing and the Earth's Environment".

The proceedings of those events have been issued as ESA special publications (ESA SP-283 and ESA SP-301 respectively).

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* Through accession of the German Democratic Republic to the Federal Republic of Germany with effect from 3 October 1990, the two German States have united to form one sovereign State. As from the date of unification, the Federal Republic of Germany acts in the United Nations under the designation "Germany".

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During the past two years ASA has organized, co-sponsored or hosted the following international symposia and seminars:

- Fourth International TOVS Study Conference, 16-22 March 1988, Igls;
- Astroseismology Workshop, 5-7 December 1988, Vienna;
- Second International Workshop on "Image Rectification of Spaceborne Synthetic Aperture Radar, 11-13 January 1989, Loipersdorf;
- World Tech Vienna - Exhibition, 18-22 June, Vienna;
- International Congress of the Meteoritical Society, 31 July-4 August 1989, Vienna;
- International Workshop on Planetary Studies, Saturn (CASSINI), Mars (PHOBOS), 1 October 1989, Graz.

2. RESEARCH INSTITUTES

2.1. Austrian Academy of Sciences, Space Research Institute, Graz

2.1.1. Department of Experimental Space Research

Much of the work in this Department is carried out in close co-operation with the Institute of Communications and Wave Propagation of the Technical University Graz; in order to avoid duplication some of these activities are reported below.

Planetary and interplanetary fields

Project PHOBOS

On 7 and 12 July 1988, the space probes PHOBOS 1 and 2 were launched from the Soviet space centre Baikonur, respectively, on their journey to Mars and its moon Phobos. Austrian instruments aboard these spacecraft were the magnetometer MAGMA, parts of the plasma experiments SOWICOMS and TAUS, as well as contributions to the Phobos surface experiments DION and LIMA-D.

The mission worked as planned until the loss of the probe PHOBOS-1 in September 1988 due to an erroneous command from the control centre in Moscow. Since both spacecraft carried largely the same instrumentation, about 90 per cent of the tasks of the interplanetary part of the mission and of the investigation of Mars could be carried out. Upon arrival at Mars on 29 January 1989, the spacecraft was transferred to a highly elliptic equatorial orbit. After four revolutions around the planet, the trajectory was corrected to become circular, almost the same as that of the moon Phobos. Due to a failure in the orientation control which quickly led to energy exhaustion, PHOBOS-2 was lost on 27 March 1989. Up to that time, only a few images of Phobos were taken, whereas the investigation of the plasma environment of Mars was done in detail.

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The magnetic field experiment MAGMA together with the plasma experiment TAUS provided excellent data about the state of the interplanetary medium along the probe's path to Mars. During many orbits around Mars between 1 February and 26 March 1989, PHOBOS-2 performed magnetic field and plasma measurements with a hitherto unavailable time resolution. The spacecraft's orbit also allowed for the first time a detailed study of the Martian tail. The analysis of the data showed a correlation between the upstream interplanetary magnetic field and the tail field. This can be interpreted in terms of an induced Martian magnetosphere (at least outside the orbit of Phobos), a feature well known from Venus. However, there are also indications in the data that Mars exhibits a weak, small-scale intrinsic field. Due to the high time resolution of the measurements new boundaries have been discovered in the plasma environment of Mars. Also, some features in the data suggest the existence of a dust torus along the orbit of the moon Phobos.

Data obtained on the elliptic orbits revealed a turbulent bow shock with a strong foot associated with reflected protons, while data from the circular orbits show high variations in the terminator location of the bow shock.

Interplanetary medium and comets

As part of the "Multi-Spacecraft-Study" primarily the raw data were recorded from the interplanetary measurements of the magnetic field experiment MISCHA aboard the spacecraft VEGA during the period December 1984 to June 1986. The data were corrected and put on a master-file, which also contained attitude data of the spacecraft as well as solar data and information about data correction. The main problem in the processing of the raw data was the determination of the intrinsic field of the spacecraft. This could be calculated by using two magnetic field sensors with dedicated calibration manoeuvres and statistical methods. A search of the data thus re-calibrated was begun for such phenomena (e.g., sector boundaries) in the solar wind, which are closely related to processes in the coma of Halley's comet (e.g., tail disconnections). The *in-situ* VEGA measurements were compared with optical ground-based observations of Halley's comet. These investigations were carried out in close co-operation with the Goddard Space Flight Center (NASA/GSFC), which, in the framework of the International Halley Watch (IHW), made available pictures of Halley's comet.

In 1988 comparative studies of magnetic field fluctuations in the vicinity of the comets Halley and Giacobini-Zinner were begun. For this purpose the data of the Austrian magnetometer experiments aboard VEGA 1 and 2 and the those of the Jet Propulsion Laboratory (JPL) magnetometer aboard the United States comet mission ICE were used. In addition a one-dimensional plasma computer simulation model was available. A first aim of the study, carried out jointly with the University of California at Los Angeles (UCLA), and JPL (Pasadena, California, and Los Alamos, New Mexico) was to investigate the energy density of magnetic field fluctuations in the region of proton and water ions and their dependence on the distance of the planetary nucleus. It was found that in the case of both comets the wave amplitudes decay as expected with distance, but in the immediate vicinity these fluctuations also decrease. A joint analysis of the magnometer data and the high-energy particle data aboard VEGA revealed quasi-periodic structures in the ion

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fluxes, which were observed outside the bow-shock of Halley's comet and may have been generated by enhanced gas production at the surface of the cometary nucleus. Structures with similar periodicities were observed by the particle detectors of the spacecraft GIOTTO during the fly-by of Halley's comet. The spin of the comet's nucleus led to periodic variations of the neutral gas density in the vicinity of the comet and thus the ions detected by the plasma diagnostic instruments aboard the VEGA spacecraft. The spin period of the nucleus of 53 hours requires a neutral gas velocity of about 6 km/s in order to explain the observed quasi-periodic structures. Such high velocities of the neutral particles could be the result of recombination processes in the coma's interior. The analysis of the VEGA data was greatly facilitated by the software package TANAL (Trajectory ANALysis), which allows interactive processing of the magnetic field data along an interplanetary trajectory. The necessary software had been developed in the past years jointly with UCLA.

Mars-94 (MAREMF, MAGBALL and SIP experiments)

Mars is one of the main objectives of the Soviet space programme for the next two decades. The two MARS-94 space probes, scheduled for launch at the end of 1994, will investigate the environment of the planet. The Martian surface will be investigated by the MARS-94 balloons and landers. The Department submitted proposals for two experiments: MAREMF (combined magnetic field and plasma electron investigation in the Martian environment and in interplanetary space) fully accepted by the MARS-94 management, will investigate the magnetic field and the electron plasma component near Mars; MAGBAL (Magnetic field investigation aboard the balloon) should investigate the low- and high-frequency fluctuations of the magnetic field near the surface. MAREMF and MAGBAL are joint experiments with institutes from Austria, Belgium, Germany the United Kingdom of Great Britain and Northern Ireland, Ireland, Hungary, the United States and the Soviet Union.

In order to investigate the ionosphere of Mars a multi-directional retarding potential analyser (RPA) will be flown in the MARS-94 mission, provided jointly by the USSR, Czechoslovakia, Ireland and Hungary. A spherical ion probe (SIP), which will be built by Austria (Technical University Graz) will at the expense of angular resolution, provide high time and density resolution of the ion densities. In addition it will serve as a back-up for the rather sophisticated multiple RPA and at intervals provide ion temperature measurements.

Experiments to control the satellite potential

The electric potential of a satellite is a function of the plasma in its vicinity; conversely, the measurability and accuracy of most plasma parameters detected by instruments aboard the satellite depends to a large extent upon the satellite potential. It has been known for some time that a knowledge of the thermal or low-energy component of the plasma is essential for its overall understanding. Particularly with regard to the measurement of the low-energy part, it is crucial that the presence of the satellite not influence the plasma particles.

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Satellite Potential Control SPEX/Project INTERBALL

Upon the invitation of, and in co-operation with, ESA (ESTEC) the Department is participating in a satellite experiment for the active potential control using an ion beam (SPEX = satellite potential experiment). The satellite is to be launched as one of four spacecraft of the Soviet INTERBALL project in 1992. It will have a very eccentric, near-polar orbit (perigee 700 km, apogee 20,000 km, inclination 65°) in order to measure the inner magnetosphere. The emphasis of the observations is on the dynamics of electrically charged particles and fields in the polar cap and the auroral zone. It is known that near apogee, in the Sun-lit part of the orbit and outside the plasma sphere, electric equilibrium potentials of a few volts with peaks of +100 V may occur. The instrument under construction is designed to compensate these potentials to nearly zero. The onboard E-field measurement is used to control the emitted ion current.

Satellite Potential Control ASPOC/project CLUSTER

Based on the concept of the satellite potential control experiment SPEX (INTERBALL), the joint experiment CLUSTER was proposed for the International Solar-Terrestrial Physics (ISTP) mission by ESA and NASA. The following co-operating institutions are involved: Austrian Research Centre Seibersdorf; Space Science Department of ESA/ESTEC; Norwegian Defence Research Establishment; University of New Hampshire at Durham; Naval Postgraduate School at Monterey, California; University of California at San Diego, California; and Jet Propulsion Laboratory at Pasadena, California. The active spacecraft potential control (ASPOC) experiment is of particular importance for the CLUSTER mission because on the one hand the planned orbits will be largely in thin plasma, and on the other the very philosophy of the CLUSTER project is to determine differential quotients of plasma parameters employing four neighbouring satellites; hence accurate measurements of the individual satellites are vital.

Magnetosphere

Magnetic field measurements as part of the CLUSTER project

Within the ISTP mission a co-ordinated study is planned to investigate the Sun-Earth system, particularly space plasma phenomena at the edge of the magnetosphere. The envisaged application of four satellites of the CLUSTER project will allow a detailed study with high-resolution instruments of the temporal and spatial characteristics of dynamic processes both within the magnetosphere and at the boundaries. This project was officially accepted by ESA in 1988, together with the flux gate magnetometer (FGM) experiment. The Department is participating in the development of hardware and software both on board and on the ground. After a number of consultations the development of a test model for the various components was begun. The Department is currently engaged in the development of the high-resolution magnetometer using a 16 bit analog-to-digital (A/D). For test purposes an artificial magnetic field simulator was developed in order to test the magnetometer's behaviour under realistic temperatures.

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Active experiments in the ionosphere

Disturbances in the ionospheric plasma caused by artificial injection of energetic electrons are still a subject of experimental and theoretical activity. As a reaction to the electron beam there are interactions between the beam and the ambient plasma, optical emission and plasma waves. One of the novel observation was the "super potential" of the payload during the electron gun operation (i.e., potentials exceeding the gun voltage). These effects were seen on two payloads in which the Department was involved, one launched from mid-level latitudes in the Soviet Union, the other in the auroral zone from Norway. The common feature was the relatively low background plasma density. The more complex Norwegian (United States/Swedish/Austrian) payload consisted of a mother-and-daughter sub-payload. Effects of the gun operation (aboard the daughter) could be seen by instruments on the mother at distances of up to 400 metres.

Experiments aboard the Soviet space station Mir

In the framework of the AUSTROMIR project, the first Austrian Cosmonaut mission, the Department is participating in a technological experiment on board the Mir space station. The low-gravity ion emitters (LOGION) experiment is being led by the Seibersdorf Austrian Research Centre and is described in more detail in section 2.9 below. The Department is responsible for the complete electronics and software for the control including the interfaces to the central data recording system. The engineering model is in the manufacturing phase and was to be delivered in mid-1990.

2.1.2. Department of Near-Earth-Space Physics

The Department is involved primarily in theoretical, but also in experimental, research, covering the physics of the interplanetary medium, the interaction between the solar wind and solar system bodies and detailed magnetospheric processes such as planetary radio emission, magnetic field reconnection, solar terrestrial relationships and planetary aeronomy.

In close co-operation with the Institute for Meteorology and Geophysics of the University of Graz, a joint project is investigating the Jovian decametric radio emission. After having deployed a new antenna system on the grounds of the Lustbühel Observatory, covering a frequency range of 13 MHz-30 MHz, a new radio station with a multi-channel radio receiver was put into operation. The high time resolution enables the observation and recording of the so-called S- (or millisecond) radio bursts of Jupiter. The dynamic spectra of the respective bursts are visualized on a monitor which displays the colour-coded burst intensity in a frequency-versus-time diagram.

In collaboration with the Goddard Space Flight Center/NASA, United States statistical studies included the long-term modulation of Saturn's non-thermal radio emission in the kilometric wavelength range (SKR). Based on observations by Voyager 1 and 2, the analysis confirmed the solar wind momentum, ram pressure and kinetic energy flux to be the main drivers in stimulating SKR. In addition, some

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indications were found that, for limited periods of time, magnetic properties and time derivatives of the solar wind have increased importance in the process of SKR stimulation.

In co-operation with the Max Planck Institute for Aeronomy, Katlenburg-Lindau, Germany, Jupiter pre-encounter observations of Voyager 1 and 2 were used to show the extent of the influence of various solar wind quantities on Jovian non-thermal radio emission in the hectometric wavelength range (HOM). Using linear cross-correlation and power spectral analysis, respectively, and single and multi-channel time filtering of the linear prediction technique, a detailed overview was given of the influence of the solar wind on HOM. According to studies of other investigators, the solar wind density was found to be the best predictor of the HOM emission. Contrary to the general interpretation, it could be shown that the sector structure of the interplanetary magnetic field does not control HOM fluctuations.

Voyager 2-Uranus Planetary Radio Astronomy (PRA) encounter observations were used to determine the source region of Uranus' smooth low-frequency component. This analysis was performed in co-operation with the Obsevatoire de Paris, Meudon, France.

Research in the fields of cometary physics was performed both on a theoretical and on an experimental level. The results of the GIOTTO and VEGA missions to Halley's comet (1986) opened several new questions regarding the physical nature of a cometary nucleus: which mechanisms control cometary activity? What is the nature of the apparently "inactive" regions of the nucleus? How does energy transport inside the porous nucleus take place?

These questions are investigated within the framework of the Kometen-simulation (KOSI) programme, in which our Department is involved in close co-operation with DLR/Köln and German universities. Experiments simulating the effect of a porous dust mantle on the energy balance of an ice sample irradiated by an artificial "sun" have been performed using the vacuum chamber facility at DLR/Köln.

2.1.3. Department of Satellite Geodesy

The Department of Satellite Geodesy was officially established at the end of 1972 as part of the Institute for Space Research. However, one year before it had started its activities by continuing the optical direction measurements to artificial satellites carried out earlier by the Institute for National Survey and Photogrammetry of the Technical University Graz.

In view of the progress in electronics in providing more powerful (and accurate) methods for the study of the shape and the dynamic behaviour of the Earth, two Doppler receivers were acquired (funded by the Austrian Science Research Council - FWF) in early 1976. Doppler methods were used extensively until the end of 1986; various campaigns were carried out in Europe, and for the first time it was possible for a continental Doppler network of Eastern and Western Europe to be established connecting the countries of Eastern and Western Europe.

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By 1982 it was possible for a new Laser station to be installed at the Graz-Lustbühel Observatory. During the past eight years the accuracy of the laser measurements were able to be improved on a step-by-step basis. At present its accuracy is well below the cm-level; it is the most accurate station in Europe, and among the best world wide.

The Navy Navigation Satellites (NNSS) system, which has been used for Doppler observation, is now gradually being replaced by the Global Positioning System (GPS). In 1986 a TI-4100 GPS receiver was purchased by the Austrian Space Research centre (ASRC) and employed for national and international projects. In particular, a geodynamic network has been established in Austria.

Continuing its primary task of operating Austria's only geodynamic observatory as a fundamental station for monitoring the variations in time of Earth parameters and crustal movements in the context of international programmes, the Department has concentrated on activities related to satellite-laser-ranging and GPS-positioning.

The principal focus of attention was the further improvement of the accuracy of the laser. A significant step towards the "single-shot-subcentimeter-accuracy" was attained by the incorporation of a single photon avalanche diode (SPAD) in co-operation with the Faculty of Nuclear Science and Physical Engineering Prague, which replaced the former Hamamatsu multiple counting photodiode (MCP) in the summer of 1988. Further efforts to achieve this goal by improving the laser pulse quality and optimizing the signal strength and trigger levels are in progress.

About 600 passes with more than 300,000 returns have been observed with the satellites LAGEOS, STARLETTE, AJISAI and ETALON 1/2 and forwarded for computation within the projects CDP, WEGENER-MEDLAS and IERS. Full daylight capability has not been achieved to date, for logical reasons. Recently, a project has been approved which will allow for the replacement of the archaic HP-1000 system and will provide more manpower and funds for the designated goal to reach subcentimetre accuracy and full daylight capability.

The successful participation in the time-transfer experiment LASSO was a second achievement of the Department. The Graz Laser Station was the only satellite ranging station which was able to detect clear returns from the METEOSAT-P2 satellite using the system-integrated Ruby-Laser.

The activities of GPS included the computation of the GPS DÖNAV campaigns (52 sites) and the national AGEDEN campaign (47 sites) as well as the participation in the GOTEX, EUREF, CASA-UNO, ANSA, and ACORES campaigns.

The AGEDEN results can be considered as a first determination of the co-ordinates of fixed-marker sites within the geodynamical Austrian regions of interest, the Diendorferfault, the Periadriadric lineament, and the "Tauernnordrand". Repeated measurements of these sites were planned for late 1990.

In order to establish the Graz geodynamic observatory as a collocated observation site (Laser + GPS) the TI-4100 GPS-receiver was interfaced to a PC.

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The software is written in TURBOBASIC and allows for a complete emulation of the coupling display unit (CDU) and the output control including different choices of the output format (binary, RINEX).

2.2. Museum of Natural History, Vienna, Department of Mineralogy and Petrology

The Department has a long tradition in extraterrestrial research, which has always been based on its valuable meteorite collection. Meteorite and related research is a complex interdisciplinary undertaking and naturally relies on the co-operation of several specialists from a variety of institutions. Over the past few years the Department has enjoyed the close co-operation of the Max Planck Institutes in Mainz and Heidelberg, Germany, the Vernadsky Institute in Moscow, the British Museums (Natural History) in London, Washington University in St. Louis, United States, the Centre de la Spectrometrie Nucléaire et Spectrometrie de Masse (CSNSM), Orsay, France, and others.

2.3. Technical University Graz, Institute of Communications and Wave Propagation

Atmosphere, Ionosphere

Based on an extension of the Sen and Wyller magnetoionic theory, all previous rocket data using a wave propagation experiment were recalculated. The differences in the derived electron densities and collision frequencies from the results obtained by the original Sen and Wyller equations is, however, very small. The new theory treats the influence of collision frequency according to more recent laboratory results. This theory may perhaps make a little difference in the calculation of VLF propagation.

Mesopheric trace constituents and their transport

The ANODE and SISSI rocket payloads were successfully launched from ESRANGE, Sweden, in February 1990. Both payloads aimed at the investigation of minor constituents. The ANODE (Auroral Nitric Oxide Dayglow Experiment) emphasized nitric oxide, whereas water vapour was of prime interest in the SISSI trial. In both cases the Austrian instruments were part of wave propagation experiments to establish the electron density; in the case of ANODE the density of positive ions and the fluxes of energetic particles were also measured.

The investigation of the dynamics of the mesophere was the prime aim of the EPSILON rocket campaign conducted in October 1987 from northern Scandinavia. The data together with measurements by an ion mass spectrometer and an optical instrument which measured atomic exygen and temperature data, formed the basis for a case study. These measurements could be compared with the results of a model simulation and demonstrated the relevance of atomic oxygen for the chemistry of the lower D-region. The results of the EPSILON campaign were incorporated into an existing statistical model of the D- and lower E-region.

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A materials analysis instrument for the Mir space station

Future long-term space missions and the operation of manned space stations necessitate the search for solutions to the problem of space-exposure of materials and structures and interaction of space radiation (electromagnetic, plasma and microparticles) in order to ensure the safety and survival of spacecraft and space structures. Few long-term exposure experiments have only been performed, and the effects of space radiation on materials have been investigated on the basis of ground-based laboratory measurements. It appears desirable to have available a materials analysis station for the investigation of "space corrosion" (investigation of space exposure on materials) on board a manned space station for a number of reasons, inter alia:

- Opportunities for exposed materials to return to Earth may not be available in sufficient number;
- Corrosion effects affect mainly the outermost layer of an exposed surface may be contaminated during prolonged storage and handling previous to Earth return.

It has therefore been suggested to install a MIGMAS (microgravity mass spectrometer) surface analysis instrument on board the Soviet station Mir. MIGMAS is a scanning ion microprobe capable of spatial multidimensional chemical micro-analysis of materials. It is capable of performing the following analytical modes: bulk analysis; depth profiling; two- and three-dimensional imaging distribution analysis of chemical elements in solid samples.

The instrument will be assembled in two steps:

(1) MIGMAS/A consists of the vacuum system, primary ion gun and control electronics. This state will be operated as a scanning ion microscope (SIM), allowing the recording of topographic images from samples, without mass analysis. It is a technological test of the performance and stability of a miniaturized space-qualified scanning ion gun. MIGMAS/A is planned for the Austrian/Soviet mission in 1991;

(2) MIGMAS/B/C will include the monopole mass analyser and a sample changing vacuum interlock. This system is planned for a post-1991 mission.

This experiment is a joint effort with the Siebersdorf Research Centre and is also referred to there in section 2.9 below.

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2.4. University of Graz

2.4.1. Institute of Meteorology and Geophysics

The long-term involvement of the Institute of Meteorology and Geophysics of the University of Graz in using propagation effects on satellite signals continues. Since the end of the SIRIO radio beacon experiment the Institute has concentrated on observations of the differential doppler effect on the signals of the navy navigation satellites (NNSS) which give the latitude dependence of ionospheric electron content. Similar observations with dedicated equipment are made at Max Planck Institute for Aeronomy (Lindau/Harz, Germany). By combining the data from both stations as is done at Graz the quality of the results is improved and the range of latitude covered by the observations is increased. Other stations co-operate from time to time on a "campaign" basis with so-called "geodetic" receiving equipment.

Campaigns for global observation of the ionosphere have been organized in the framework of the SUNDIAL project and electron content data have been shown to be especially useful in providing information about the main F-region trough, its morphology and dynamics. Other types of campaigns are connected to the study of travelling ionospheric disturbances (TIDs) and to the assessment of propagation errors which influence all measuring systems using trans-ionospheric propagation of radio waves (as used in, e.g., satellite geodesy, radio astronomy, time dissemination from satellites, etc.). Long-term observations of ionospheric electron content are used to construct regional ionization models which are then compared with global models, e.g., with the International Reference Ionosphere (IRI). Finally, the data base collected at Graz is used for various case studies, of which investigations of magnetic storm effects are of special interest.

In addition, ground-based observations of decametric radio emission from Jupiter are being carried out jointly with the Space Research Institute of the Academy of Sciences at the Lustbühel Observatory.

2.4.2. Physiological Institute

The physiological dynamics of the human organism depend on gravity and are altered in many ways by the microgravity environment of space flight. Many aspects of physiological adaptation to altered accelerational force are not fully understood and need in-depth investigation before extended space missions can be undertaken.

The scientific activities of the Physiological Institute include aspects of space physiology and medicine. In the framework of the Austrian-Soviet mission known as Austromir, three experiments have been proposed by members of the Institute and have been accepted. Developmental work has well proceeded for flight for all three projects:

(1) "Body fluids" experiment: deals with fluid shifts within the cosmonaut's body following a controlled circulatory stimulus, i.e., lower body negative

pressure, pre-flight, inflight and post-flight. A newly developed self-powered, hand-held high-precision sound velocity meter (mass: 1.6 kg) was developed and has been dubbed the "proteinometer" since it indirectly measures protein concentration in blood and plasma samples. The design of a space-qualified blood collection kit is also part of the project;

(2) "PULSTRANS" experiment: investigates the influence of physical stresses in space on the heart rhythm and arteries during various phases of adaptation to weighlessness. In particular the circulation in the important arteries of the neck and head will be investigated. During the experiment the subject will wear a special jacket fitted with sensors;

(3) "MICROVIB" experiment: for this study, too, a "measuring jacket" will be used. Hitherto unexplained microvibrations to which the human body is subject, even when totally relaxed, will be investigated. A vibrator will also be employed to generate artificial waves. It is planned to arrive at standard measuring procedures in this area.

The Working Group for Volume Regulation and Space Medicine is continuing to conduct applied research, development and testing in the field of space medicine. The group has made contributions to space medicine during the last ten years. There is ongoing collaboration with research organizations in Europe and the United States. Part of this work has been published in the major journals in the field. The group currently employs the following strategies:

- Measurement of biomedical parameters using emerging methods that are minimally invasive, reliable, precise and easy to use. Over the last two decades, a great number of biomedical results from space flight and simulation experiments has accumulated. Flight and control experiments, however, in many cases are performed in isolation, lacking interrelation with other biological subsystems studied at the same time and/or in the same subject. This is unsatisfactory, since space-flight experiments are extremely expensive and cannot easily be repeated. The Group has therefore proposed to employ biomedical systems-analysis approaches for a sound basis of data collection and management.

- Systems analysis: integrative conceptual design for maximum scientific relevance and acceptance. Due to the complexity of biological systems, one cannot exactly predict the behaviour of any variable during experimental investigations in a living organism. Rather, a certain probability of expected dynamic output patterns can be indicated. Many different processes occur simultaneously in biological systems, and most of the subsystems involved behave in a non-linear manner. Computers can be helpful for investigating and understanding such complex systems, and in managing the data flow during multi-task experimentation, as with astronauts under rigid operational and time constraints. The group uses wide-angle view approaches for facility design and experimental timelining, e.g., for the European human physiology laboratory (Anthrorack) and the biochemical-biological analysis facility on board the Spacelab; nutrition scenarios and food management (Columbus and

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Hermes programmes); and body fluid-electrolyte shift monitoring in future missions of extended duration.

- Space-qualified hardware for future in-mission physiological measurements is being provided. Consulting work for ESA and space-technology companies (reviews, hardware concepts, mission profiles, experiment scenarios, analysis of background information) has been done. There is current work on space flight experiments designed for various mission profiles. In co-operation with other research entities in Graz, a new, miniaturized and space-qualified device for the monitoring of fluid-electrolyte and blood volume shifts has been developed.

Institute for Functional Studies and Space Medicine

This research institute is currently being formed as a separate entity, as part of the Medical Faculty at the University of Graz. Unlike most other Austrian university institutes, the Institute for Functional Studies and Space Medicine will have the ability to contract with commercial entities. The envisaged activities of the Institute will be centred around several areas, the combination of which will allow for problems analysis, study design, applied research and product development.

2.5. University of Innsbruck

2.5.1. Institute of Meteorology and Geophysics: Working Group on Satellite Meteorology and Remote Sensing

The first experience in satellite remote sensing was gained in the 1970s when Landsat data were applied to snow and glacier studies. Research activities in remote sensing intensified in 1978, when Prof. H.-J. Bolle established a research group on satellite meteorology. The emphasis of the research since that time has been on applications of satellite remote sensing to climate studies. The main research topics are:

(i) Vertical sounding of the atmosphere based on TOVS data of the satellites of the National Oceanic and Atmospheric Administration (NOAA) of the United States;

(ii) Cloud climatology based on NOAA and Meteosat data - as a contribution to the International Satellite Cloud Climatology Project of the International Association of Meteorology and Atmospheric Physics (IAMAP);

(iii) Land surface climatology using Landsat and NOAA data, in particular methods for deriving radiative properties of the land surfaces - as a contribution to the International Satellite Land Surface Climatology Project (ISLSCP) of the Committee on Space Research (COSPAR), IAMAP, and the World Meteorological Organization (WMO);

(iv) Development of methods for use of satellite data in hydrology and cryospheric research, based on satellite data in the visible, infrared and microwave ranges of the spectrum.

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The main activities during 1988-1990 were concerned with fundamental physics and methods for the use of satellite data in cryospheric research and hydrology. Preparatory work has been carried out for the participation in future space-borne synthetic aperture radar (SAR) missions of ESA (Earth Resources Satellite (ERS-1)) and NASA (Shuttle Imaging Radar (SIR-C)).

In May/June 1988 two members of the Institute participated in a field experiment in Greenland as a contribution to ISLCP. Radiative properties of the surface and the atmosphere were measured, together with meteorological parameters of the boundary layer. These data are used for developing and testing methods which enable the estimation of radiation and heat balances of the surface from Landsat and NOAA data.

Investigations with passive microwave data focused on large-scale features of the polar ice sheets and of the global snow cover. These studies were based on data of the scanning multispectral microwave radiometer of Nimbus-7 and of the Special Sensor Microwave/Imager (SSM/I) of the United States Data Meteorological Satellite Programme (DMSP) satellite. As a tool for correcting atmospheric effects in the microwave region, a radiation propagation model has been installed and modified to fulfil the remote-sensing needs.

Three experiments on the application of SAR have been accepted by ESA and NASA:

(i) "Snow and ice parameters by ERS-1 AMI data" with a test site in the Austrian Alps (in co-operation with the Institute for Image Processing and Computer Graphics, Graz);

(ii) "Active microwave signatures of the polar ice sheets by ERS-1 AMI data" (in co-operation with the German Alfred Wegener Institute for Polar Research);

(iii) "The high Alpine SAR experiment" as a contribution to the Imaging SIR-C/X-SAR Experiment of NASA, DLR and ASA.

In preparation for the SIR-C/X-SAR experiment the test site in the Austrian Alps was surveyed by a three-frequency polarimetric airborne SAR of NASA/JPL in August 1989. A C-/X-band radio/scatterometer was developed for research on microwave signatures and for comparisons to satellite measurements. In preparation for the ERS-1 experiment, signature measurements were carried out in Antarctica with the system between December 1989 and March 1990 during a inland traverse organized by AWI.

2.5.2. Neurological Clinic

Despite many attempts to study human behaviour in space flights, only a little research has been performed on the impact of microgravity on the so-called higher cognitive functions in man. COGIMIR, an experiment based on principles of cognitive neuropsychology, aims at the assessment of highly developed skills such as visual-motor co-ordination, memory and visual-spatial processing during the

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early and late phase of the Austromir space flight lasting six days. The COGIMIR experiment uses a microcomputer system equipped with special software for stimulus presentation and for exact recording of the subject's reactions. Stimuli are all visual and are presented on a monochrome screen; reactions are given on a keyboard and recorded in terms of accuracy and reaction time.

A number of different tests have been developed for this purpose. COGIMIR will assess simple and choice reaction times, visual-spatial processing by use of two line-orientation tests of graduated difficulty and continuous attention by an arithmetic task. Learning abilities for spatial working memory will be evaluated by a letter and an object location paradigm. To avoid floor or ceiling effects in well trained persons, these tasks will be adapted as cognitive profile and training standards of future cosmonauts by changing test variables such as number, presentation time and configuration of the visual stimuli. The actual procedure will consist of a sequence of tasks with different stimulus material but comparable difficulty; sessions will be repeated before, during and after the flight. The use of specially designed tasks and microcomputer assessment is a more objective approach to the problem of brain/behavioural relationships under conditions of space.

A new system for human motion analysis (MONIMIR) is being developed for use on the first Austrian-Soviet space flight in 1991 aboard the Mir space station. This system enables the subject's body movements to be registered using a combination of infrared light-emitting diodes (LEDs) attached to the various parts of the body to provide the "target" and 2 x 2 infrared line cameras surrounding the subject to trace these targets.

A device consisting of a light beam attached to either the subject's arm or head, together with a LED matrix, provides a means of standardizing the subject's movements. A further device is provided to enable the recording of the following associated neurophysical signals: electro-oculogram (EOG), electromyogram (EMG) and electrocardiogram (ECG).

In addition to its space-related applications (e.g., in connection with MONIMIR further applications for this new system for motion analysis are foreseen in the fields of neurology, neuromuscular physiology, sports medicine, occupational medicine and rehabilitation.

This project is carried out in conjunction with D. P. Fanak Data Processing, Vienna.

2.6. Technical University of Vienna, Department for Photogrammetry and Remote Sensing: Austrian "Remote Sensing" Joint Research Group

Within the Soviet-Austrian manned flight AUSTROMIR a remote-sensing experiment (FEM) will also be carried out. The objective of the experiment is the verification and enhancement of existing atmospheric models and their parameters for remote-sensing applications in Austria.

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On board the Mir station only existing equipment will be used:

- Multispectral camera MKF-6MA: A photographic system with 125-mm lenses, producing 6 frames 55 x 80 mm in various spectral ranges between 480 and 840 nm;

- Spectrometer MKS-M: Non-scanning instrument, consisting of: Block AS: IFOV 0.46 x 0.46°, 12 spectral bands between 415 and 880 nm with a bandwith of 10 nm for each channel and Block BS: IFOV 1.14 x 0.09°, 6 spectral bands in the range 758-823 nm and a very narrow bandwidth of 1.5 nm.

During the planned one-week mission, two daytime passes over Austrian territory will occur. At these events both sensors are to be operated simultaneously by the Austrian cosmonaut: the camera will take stereoscopic photographs of a large part of Austria while the spectrometer is measuring a multi-spectral profile of backscatter in the nadir direction.

An essential part of the experiment is the various measurements that will be taken in Austria during the passes of the orbital station: At several locations the actual spectral response of different kinds of vegetation and soil, as well as the radiation transmitted and scattered by the atmosphere, will be observed by means of portable spectrometers. It is also planned to use a surveying aircraft for infrared photography of test sites from different heights. These images will be affected by different layers of atmospheric disturbances (due to the distance above ground), while photographs and data taken at the Mir station will contain effects of the whole atmosphere.

The data gathered in space and on ground during the AUSTROMIR mission will mainly be analysed with respect to their correlation with atmospheric parameters. It is intended also to use remote-sensing data from other sources for the investigations, if they are taken at about the same time. The scientists involved hope to improve their knowledge with regard to the applicability of different atmospheric models under the meteorological circumstances of Austria. The constants used within these calculations will be checked and, if necessary, specified anew.

Most of the members of the Austrian remote-sensing joint research project will be involved in utilizing the data, in co-operation with Soviet institutions. The Austrian group has an interdisciplinary structure and includes specialists on various aspects of remote sensing from several institutes and research laboratories.

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2.7. University of Vienna

2.7.1. Institute of Astronomy

The Institute of Astronomy entered the space age in 1972, when in co-operation with Dutch colleagues it applied successfully for carrying out time observations from the TD1-A/S 59 ESRO satellite. The target was HR-15, a star having a peculiar chemical make-up, with an overabundance of manganese. Spectroscopic variations in the ultraviolet, consistent with an oblique rotator model, were detected. To gather more detailed data for quantitative analysis, a follow-up programme was developed for the Copernicus satellite, operated by NASA. Short periodic variations as well as those related to the rotation period were investigated and indications for mass loss due to a stellar wind were obtained.

Spectrometic investigations of stars with a peculiar chemical make-up were continued after the International Ultraviolet Explorer was launched in January 1978. High- and low-resolution spectra of normal stars as well as various chemically pure stars were obtained and published in co-operation with astronomers in Germany, Italy and Spain. Recently, the institute has participated in the observation programmes of the NASA/ESA Hubble Space Telescope and the ESA astrometric satellite Hipparcos.

In general, the space related activities of the Vienna Institute consist of: (a) using various existing scientific payloads for astrophysical research; and (b) international co-operation to define and build such payloads. From the standpoint of astrophysics, two centres of interest for space-related research can be defined: (i) stellar seismology; and (ii) late stages of stellar evolution.

The principal collaborating institutions for the research projects mentioned above are the Institute for Nuclear Physics of the Technical University of Vienna, the Institute for Astronomy and Astrophysics of the Technical University Berlin (Germany), the Max Planck Institute for Astrophysics, Garching (Germany), the Observatoire de Paris (France), the European Southern Observatory (Germany, Chile), the Instituto de Astrofísica de Canarias (Spain) and the Institute of Astronomy, Cambridge (United Kingdom).

2.7.2. Institute of Geochemistry

Activities related to space research are concentrated in the areas of cosmochemistry, meteorite and lunar sample research, and on those aspects of the geosciences that involve the Earth in relation to the solar system, as well as the early history of the Earth. The recent activities are a continuation of research that has been carried out over the past two and a half decades. Earlier investigations dealt with trace element determinations in meteorites and selected lunar samples, while during the past decade the emphasis has been broadened to include terrestrial impact processes (studies of impact craters and impact products), meteorites from Antarctica, cosmic microspherules, the early Earth and related topics. Many studies are carried out in collaboration with institutions in Austria, the United States, South Africa, the Union of Soviet Socialist Republics, Germany, France and Japan.

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2.7.3. Institute of Experimental Physics

The aim of the BRILLOMIR experiment as part of the Austromir mission is the study of the critical decomposition of binary liquid mixtures under microgravity conditions. The experimental set-up consists of a white light source, a thermostatis cell with the liquid mixture and a high-resolution black-and-white video camera with a S-VHS video tape recorder. The temperature of the sample is regulated to ± 0.001° K with the aid of a Peltier element, a Pt-resistor of 1,000 ohms and a microprocessor. The measuring time for two samples during the Mir mission will be about 12 hours on two days. Two different samples will be studied for six hours, respectively. During one experimental run, the sample will be heated to about 10° K above the critical temperature and homogenized by mechanical shaking. The sample will then be cooled very slowly below the critical decomposition temperature. Within the six hours' experimental time, this cycle will be repeated with different cooling rates. Also, one experiment will be performed quenching the sample from a temperature slightly above the critical temperature to a lower temperature, with a temperature difference of about 0.01° K. The decomposition processes will be recorded on videotape at all stages during the temperature cycles. The evaluation of the data will be performed with digital image procedures. The final results will be compared with the corresponding Earth experiments and light scattering measurements.

2.7.4. Neurological Clinic, Laboratory for Eye Motion

The most likely causes of disturbed self-orientation in space flights are the mismatch between vestibular (mainly otolithic) and visual inputs and the reinterpretation of ambiguous visual cues. In weightlessness visual information seems to be more important for spatial orientation than it is under conditions of the Earth's gravitational pull.

A laboratory experiment known as OPTOVERT was developed to provide predominance of the visual stimulus over the otolithic and somato-sensible input even in normal gravity. A subject is confronted with vertically moving patterns (black-and-white stripes or a random dot pattern) and a central fixation point for voluntary gaze fixation, thereby creating a sensation of subjective vertical motion, which is designated vertical vection perception (VVP). It seems to be possible that vertically moving patterns (with or without VVP) are a good visual stimulus for spatial orientation in microgravity. However, there are many theoretical objections and other questions to be discussed with regard to the practical use of this kind of visual stimulus in space flight. Related experiments are planned for the Soviet-Austrian Austromir mission in November 1991.

2.7.5. Institute of Sports Physiology

The MOTOMIR experiment is a joint effort with D. P. Fanak Data Processing Ltd., Vienna (Dr. M. Mossaheb), involving a new constant-velocity ergometer being developed for use on the first Austrian-Soviet space flight to be carried out in 1991 aboard the Mir space station.

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This ergometric device provides a means of expending human energy in exercising either the arm or the leg muscles while making the following movements: (a) translatoric movement (constant velocity) within a definable angular range; or (b) cyclic and acyclic movements, both parallel and diagonal, in the sagittal plane.

The following ergometric characteristics can be adjusted: joint angle, angular velocity, contraction frequency, and contraction-expansion ratio per cycle.

During the performance, the following test parameters can be measures: (a) force-time relationship in real time mode, using strain gauge system with angle positioner; (b) concentric and eccentric forces for each extremity, either individually or combined; and (c) involuntary contraction forces during application of concentric or eccentric forces.

In addition to its potential use during long-duration space flight, further applications for this new ergometer are foreseen in the fields of muscle physiology, neuromuscular physiology, sports medicine, occupational medicine, neurology, cardiology and rehabilitation.

2.8. Joanneum Research Graz, Institute for Applied System's Research

The DATAMIR central data-processing system is part of the payload in the AUSTROMIR project. The main requirements and design rules for hardware and software are the following:

- data acquisition and collection via analogue and digital data links;
- mass storage for immediate data acquisition for about 40 MByte;
- mass storage for long-term storage of about 300 MByte;
- up- and down-link via the Soviet telemetry system;
- standard operating system also to run commercial software;
- menu-controlled user surface;
- control of the experimental time line;
- evaluation of information of the live maintenance system, by use of the telemetry link;
- graphic facilities for data presentation;
- instruction and assistance screens.

The computer system is based on a standard industrial computer (compatible with IBM 286) developed in Austria and already in use for industrial automation and medical instrumentation.

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2.9. Seibersdorf Austrian Research Centre

2.9.1. Department of Physics

A spacecraft in high Earth orbit becomes positively charged, due to the emission of photo-electrons from the surfaces by solar UV-irradiation. The positive charge can reach up to >50 V with respect to the plasma. It has been suggested that this charge be compensated by the intentional emission of a beam of positive ions. This requires an ion emitter on the spacecraft with minimum mass and power requirements and a lifetime of several thousand hours. For this purpose it was proposed to use a liquid metal field emitter. The suggested emitter uses indium as a charging material and requires less than 0.5 W for operation. It can emit a beam of nominally 6 kV energy and 10 μA intensity into a total cone of 30°. The indium is enclosed in a charge container which is heated up to 210° C by indirect resistive heating. The molten indium wets a fine needle which is typically at 6 kV positive potential with respect to spacecraft (S/C) ground. An ion beam is extracted from the liquid indium at the tip of the needle by field evaporation. The emission current is controlled by the tip potential. These emitters are envisaged for active S/C potential control on the Soviet INTERBALL mission and the ESA/NASA CLUSTER project. The experiments are also described in section 2.1.1 above on the work of the Space Research Institute of the Austrian Academy of Sciences (Department of Experimental Space Research), which is leading the experiment on CLUSTER.

The Austrian-Soviet Mir flight will provide a good opportunity to test the behaviour of the source under conditions of microgravity. Thus, optimized software control programmes can be designed for automatic operation of the emitters on INTERBALL and CLUSTER. On the Mir flight, these emitters will be tested in a hermetically closed, ion-pumped vacuum system. The LOGION (low gravity ion emitters) experiment will provide automatic data acquisition of all essential operating parameters. In addition, the emitters will be returned to ground after the mission for morphological and analytical post-examination. This project is a joint effort with the Department of Experimental Space Research of the Space Research Institute of the Austrian Academy of Sciences in Graz.

2.9.2. Department of Biology and Toxicology

Immune reactions are important and necessary defence mechanisms of the human body. Their impairment leads to an increased infection rate and increased tumour incidence. Lymphocytes play a decisive role in the immune response of the organism. Discrete lymphocyte subsets co-operate in the cellular defence against viruses and bacteria, as well as in antibody production directed against diverse antigens. American and Soviet investigations point towards a decreased functional activity of lymphocytes, but no data on the diverse lymphocytic subsets exist. One goal of the present MIRGEN project on the Austromir mission is therefore to enumerate the sub-populations of immuno-competent cells by monoclonal antibodies directed against surface antigens of lymphocytes to gain insight into the composition of lymphocyte subsets and their possible alteration by exposure to low gravity and low doses of ionizing radiation. Furthermore, low gravity and ionizing radiation could affect the genetic information of the cell or special enzymes or co-factors necessary for DNA (deoxyribonucleic acid) metabolism. Damage within DNA has to be recognized and repaired by the cell to maintain the integrity of the genetic information. The present project will try to verify structural modifications of DNA and measure DNA repair after the space flight. Ultracentrifugations of chromatin will be used to measure damage in DNA. Unscheduled DNA synthesis and the induction of sister chromatid exchange by alkylating agents will be used to follow DNA repair.

2.10. Austrian Nuclear Institute, Vienna

The aims of the present DOSIMIR experiment within the Soviet-Austrian manned AUSTROMIR space mission are:

- Dosimetric monitoring of the Austrian cosmonauts by tunable diode laser (TDL) and nuclear trace films;

- Development of a method which will hopefully allow in addition to the absorbed energy (dosis) to yield some information on circular polarization (CP) and the linear energy transfer (LET) of the absorbed radiation with only one dosimeter.

The flight model consists of two dosimeter packages. In these packages there are thermoluminescence dosimeters of different materials (Li-7, Li-6, CaF_2 and $CaSO_4$:Dy) and nuclear trace films with corresponding sets of metal filters (foils). One package has the dimensions of 75 x 45 x 20 mm and will be exposed before and during the Soviet-Austrian mission. After the flight the data will be evaluated by a method specially developed by the Institute.

The information on ionizing radiation is stored directly in the crystal lattice of the TL-dosimeter in the form of energy. In the evaluation these crystals are heated and give off this stored energy in the form of light. Its intensity is measured with a photomultiplier and is a measure of the absorbed dosis. Usually light emission at temperatures of up to 300° C is used. The method developed at the Institute, a combination of temperature-optical excitation and temperatures up to 650° C, allows one to deduce information on the nature of the radiation and LET. In the case of the nuclear trace film, the number of incident particles accumulates in the form of material defects, which can be made visible by chemical methods and counted by electronic means.

2.11. AKG (Akustische Kino-Geräte GmbH), Vienna

Psycho-acoustic experiments require precisely defined acoustic ambient conditions which cannot be achieved in a space station. Therefore, signals can only be presented through headphones.

In order to produce the same sensations as test signals presented in a free sound field, the signals need to be modulated in the same way as they would be on

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their natural path from the source through the outer ear (which in this context comprises the auditory canal, pinna, head and trunk) to the eardrum. The influence of the outer ear (outer ear transfer function, OETF), which is masked in normal headphone listening, can be simulated in terms of amplitude and phase by digital filters.

In order to simulate various angles of incidence, the OETFs of the two Austrian cosmonauts for all desired angles had to be established in the AUDIMIR experiment.

The hardware for the experiment essentially includes a signal processor system and headphones. The test signals (e.g., noise bursts) digitally stored in the SIGNAL ROM are modulated by the signal processor (MOTOROLA DSPP56001) with the transfer functions stored in a RAM and fed via DACs to the headphones. The desired angle of incidence is controlled and selected by the DATAMIR central computer system via a serial interface.

For one part of the experiment the orientation of the head needs to be known in order to control the sound source location. This information will be provided by the measuring system designed for the MONIMIR experiment.

The experiment will take about 20 minutes and will be performed twice, on the second and fifth days of the cosmonauts stay in the space station. The experiment comprises two parts, with different objectives:

(1) Investigation of the influence of zero-gravity environments on the accuracy of sound source localization: This part of the experiment is designed to determine localization accuracy over part of the median and horizontal planes as compared to reference tests done on Earth. Prior investigations of the peculiarities of localization in humans in a simulated zero-gravity environment by Soviet scientists have shown transient variations in localization accuracy and a lateral shift of the image location.

(2) Investigation of the interaction between binaural hearing and the human orientation system in a zero-gravity environment: This part of the experiment is based on the assumption that in a zero-gravity environment auditory orientation is particularly important. In order to measure the influence of auditory cues on human orientation, the cosmonaut is presented with several acoustic situations while slowly moving his head:

(a) The sound source appears to remain fixed in space (as in "natural" hearing situations which permit auditory orientation);

(b) The sound source follows the head movement (as in conventional headphone listening, which permits no auditory orientation);

(c) The movement of the sound source does not correlate with the head movement. During and after the experiment, the cosmonaut will record his sensations on a dictaphone. In addition, an electro-oculogram will be recorded in order to capture any nystagmus.

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The experiment is based on recent psycho-acoustical discoveries as well as technological advances in digital audio signal processing which enable these discoveries to be utilized in engineering. The project is a joint effort with the Institute of Medical-Biological Problems, Moscow.

3. OTHER SPACE-RELATED ACTIVITIES

3.1. Technical University Graz, Institute of Communications and Wave Propagation

Timekeeping and time comparison

Because of the high stability of the time scale UTC (TUG) - as required for the establishment of "best time scales" for the study of millisecond (ms) pulsars, at the timekeeping station a GPS receiver on loan from the National Bureau of Standards (NBS) was installed in 1988. The receiver was brought to Graz by NBS personnel, who also carried out a time comparison at the Observatoire de Paris en route. In addition to the existing one, the receiver was integrated into the measuring set-up and the necessary software installed.

Since September 1988, TV signals from the satellites ECS-1 and ECS-2 have been received for test purposes. These signals are used for time comparison with co-operating institutions in Italy, Poland, Germany and the Netherlands. Two-way satellite experiments using communication satellites were also carried out.

After the successful positioning in orbit of METEOSAT-P2 and the completion of all system tests, the LASSO (laser synchronisation from stationary orbit) experiments were begun. Aside from the lunar ranging station of the Observatoire du Côte d'Azur, Grasse, France, the satellite laser ranging station at the Lustbühel observatory was the only station which participated successfully in the first phase of the LASSO experiment in 1989.

Meteorological radar for satellite propagation research

The dedicated, dually polarized meteorological radar (Hilmwarte Graz) was used to simulate satellite paths for frequencies between 12 and 50 GHz; those measurements were supplemented by an array of radiometers in the Graz area. This activity was carried out in the framework of ASTP-3 and the raw and pre-processed data were delivered to the European Space Research and Technology Centre (ESTEC). The existing software was extended to allow correlations between co- and cross-polarized echoes. These results enable conclusions to be drawn concerning drop size and inclination. These values entered are responsible for the unwanted depolarization observed in satellite signals where frequency reuse is applied. As part of the ASTP-4, an extension to allow Doppler and velocity observations is envisaged.

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3.2. Joanneum Research, Graz

3.2.1. Institute of Image Processing and Computer Graphics

Since 1980 the Institute has carried out research in the field of remote sensing with an emphasis upon radar. In the last few years it has also acquired significant experience in the fields of imaging spectrometry and the application of remote sensing to high-mountain cartography.

The Institute mainly deals with digital image analysis and remote sensing applying methods of artificial intelligence. Another area of strength is geo-information technology and generative three-dimensional computer graphics. The Institute enjoys an international reputation, which is also evidenced by its close co-operation with leading multinational industrial partners and international organizations, such as ESA, NASA, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Industrial Development Organization (UNIDO).

The processing of graphical data in the above-mentioned fields will gain significant importance in the near future for the assessment of environmental conditions. Remote sensing, supported by three-dimensional realistic computer graphics, is used for environmental monitoring, planning and design.

3.2.2. Institute for Applied Systems Research

Satellite communication

The Institute of Applied Systems Technology (IAS) Graz developed under an ESA contract and in co-operation with the Instituto CNUCE (Italy) and the Rutherford-Appleton Laboratory (United Kingdom) a new satellite transmission system which interconnects local area networks by communications satellites over long distances using time-division multiplex access and demand-assignment methods for optimum utilization of the available transmission capacity (currently 4 Mbit/s).

In addition to the transmission of computer data, the system supports digital video and voice for multi-media applications required for the distributed office environment and international research organizations. The project is designated SATINE (Satellite Internetworking Experiment) and has been initially tested and successfully demonstrated to the public using satellites of the European Telecommunications Satellite Organization (EUTELSAT). Since October 1989 the experiment has utilized ESA's experimental satellite OLYMPUS. In addition to the 12/14 GHz payload, the OLYMPUS satellite offers a new frequency band (20/30 GHz). For this purpose a transportable Earth station satellite was developed which is now the second Earth terminal in Graz. Adaptive transmission techniques are being studied and implemented to cope with deep fade propagation effects at these high frequencies and to ensure a constant quality of service for the user.

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In support of these activities IAS also developed a unique simulation system which combines the advantages of hardware and software simulation. New digital modulation and coding methods are being investigated.

Another important ESA project in this area is DICE (Direct Inter-Establishment Communications Experiment), which is a multi-point, continuous-presence video-conferencing trial using the 20/30 GHz payload of OLYMPUS. IAS developed four transportable video-conferencing and graphics units for ESA which can be used in a normal office and which provide the user with nearly all the communications facilities of a conventional meeting. A sophisticated adaptive communications system designed and built in co-operation with Austrian industry (Schrack Aerospace, Vienna) provides a powerful means for fade countermeasures.

IAS is also involved in the definition and realization of an experiment involving very small aperture terminals (VSAT) known as CODE (Co-operative OLYMPUS Data Experiment), which uses very small terminals for the dissemination of archive data, particularly images.

3.2.3. AUSTROMIR, Austrian Cosmonaut Project

In 1991 the first Austrian will travel into space. An Austrian scientific cosmonaut is to fly in November 1991 together with two Soviet colleagues to the Mir space station. During the six-day mission he will carry out 14 scientific experiments. The flight is the result of an intergovernmental agreement between the Soviet Union and Austria signed in 1988. The organizational and financial responsibilities are shared by the Federal Ministry of Science and Research on behalf of the Austrian Government and by Glavkosmos on behalf of the USSR. Within Austria, Dipl.-Ing. O. Zellhofer and Dr. U. Unterer (both of the Federal Ministry of Science and Research) are in charge of the overall project co-ordination, Prof. Dr. W. Riedler (Joanneum Research) the scientific co-ordination and Dr. M. Berger (University of Innsbruck), medical aspects.

The two candidates for the flight to the Mir Soviet space station have been trained since January 1990 at the Yuri Gagarin training centre in Zvezdmyi Gorodok (Star City) near Moscow. The choice of the 26-year-old medical doctor Clemens Lothaller and the 29-year-old electronic engineer Franz Viehböck was made after lengthy psychological and medical testing, in both Austria and the Soviet Union, of nearly 200 applicants.

The Joanneum Research acts on behalf of and in co-operation with the Federal Ministry of Science and Research as the liaison between the Soviet Glavkosmos organization and the 14 individual experimenters, helps to provide the necessary documentation, performs space qualification tests and issues the required certificates.

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3.3. Central Institute of Meteorology and Geodynamics

To date the Central Institute for Meteorology and Geodynamics has been utilizing a secondary data user station (SDVS) device with some image processing such as artificial colour, movies and zooming, which has been developed at the Institute; a primary data user station (PDUS) device is currently in the testing stage.

Satellite images from polar orbiting as well as geostationary weather satellites have been received and used in the operational weather service for many years; an archive of satellite images serves as the basis for research work in the field of satellite synoptics.

The primary objective of the work with satellite images is the diagnosis of typical, frequently occurring cloud configurations in relation to the physical state of the atmosphere. For the latter the total basic synoptic material, such as radiosonde values, weather observations and numerical parameters (initialized and prognostic fields), is used. This is called the SATMOD (satellite images and model output diagnosis) method. Work in this field has led to the classification of typical satellite-synoptic categories which are diagnosed daily and issued in the form of a Satellite Report (SATREP) to all weather services in Austria.

CUBA

[Original: Spanish]

On 18 September, Cuba observed the tenth anniversary of the joint space flight of cosmonauts Arnoldo Tamayo of Cuba and Yuri Romanenko of the Union of Soviet Socialist Republics.

The flight of the first Latin American in outer space gave considerable impetus to space research in Cuba, with special emphasis on medicine, remote sensing, meteorology, space physics, communications and materials science.

In space physics, special attention was devoted to the study of near space and Cuba participated actively in a number of international projects for the study of the ionosphere, the magnetosphere and the relationships between the Sun and the Earth.

Work is currently being carried out on the design and construction of equipment for physical research on automatic spacecraft which, for a developing country such as Cuba, an opportunity to introduce leading-edge technologies and new methods of design and construction.

In the field of physics, the development of geodesy and geodynamics in connection with the use of satellites has led to improvements in the National Geodetic Network and made it possible to identify regular patterns in the recent vertical movements of the Earth's crust in the seismically active zone of the eastern part of the country, and other aspects of economic interest.

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Satellite meteorology has made a fundamental contribution to support services for weather analysis and forecasting. With the information received daily, weather map analysis has improved and short-term forecasting criteria and warnings on potential damage by hazardous phenomena can be issued. It is now impossible to conceive of meteorology in Cuba without the use of space techniques.

Application of the results of remote sensing has led to the discovery of seismic sources and major geological structures and faults. It has become possible, inter alia, to draw maps showing soil erosion over large areas; study agricultural soils affected by salinity; and identify the movement of port pollutants.

Of particular interest is research which combines the application of modern remote-sensing techniques with traditional methods. A case in point is the multidisciplinary work done by our experts in their study of island groups and coastal areas of the Cuban archipelago with a view to the development of tourism and environmental preservation.

Cuba is continuing its work in the field of space medicine. Proof is the recent development of neurological equipment which affords a better understanding of human beings subjected to extreme conditions, both in permanent space stations and in the complex tasks of modern life. Studies of human motor functions during space flights and their readjustment and other interesting aspects applicable to sports medicine and clinical care are also being continued.

INDIA

[Original: English]

The Indian Space Programme organized under the Department of Space, Government of India, is mainly aimed at self-reliant development of space technology and its applications for the rapid socio-economic development of the country. The programme also aims to promote appropriate international co-operation and includes scientific exploration in space sciences as one of its components. The major application areas include telecommunications, meteorology and the survey of natural resources. These are pursued through space systems including satellites and launchers and ground operational systems. An overview of progress achieved in 1989-1990 under various segments of the programme and the aspects related to international co-operation are presented below.

Indian remote-sensing satellite

The Indian remote-sensing satellite IRS-1A is the first in a series of indigenous state-of-art remote-sensing satellites. Since its launch on 17 March 1988 on board the Soviet Vostok rocket, IRS-1A has been functioning well and has become the mainstay for the national natural resources survey and management programme. The satellite, weighing 975 kg, has on board two linear imaging self-scanning sensor (LISS) cameras, LISS-I and LISS-II, with resolutions of 73 m and 36.5 m respectively, for imaging with a swath width of 148 km.

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Data from IRS-1A are extensively used for several natural/state level application projects/missions, such as ground-water potential zone mapping, saline/alkaline soil mapping, wasteland monitoring, flood mapping and damage assessment, geological mapping, marine fisheries potential estimation, land use/land cover monitoring, snow cover mapping and development of integrated plans to combat drought.

The IRS-1B satellite has as its aim to continue the services of IRS-1A. Integration of sub-systems for the IRS-1B model has already commenced. IRS-1B will be identical to IRS-1A. Integration of IRS-1E is also in progress for its launch on board the first developmental flight of an indigenous polar satellite launch vehicle (PSLV) launcher. Work on IRS-1C and IRS-1D, future satellites in this series, has also started, and these satellites are planned to have improved spectral and spatial resolutions, revisits, stereo viewing and on-board video data recording capabilities.

INSAT-1

INSAT-1B, launched in 1983, has continued to provide operational services during 1989 in the areas of telecommunications, meteorology, television and radio networking. As many as 4,372 two-way-voice or equivalent circuits are in operational use over telecommunication routes through the Indian National Satellite System for Television and Telecommunications (INSAT). As of 30 September 1989, 28,447 meteorological very high resolution radiometer (VHRR) images had been commanded. Over 500 television and 100 radio stations belong to the INSAT network.

INSAT-1C, launched on 22 July 1988, was able to operate with only partial capacity, owing to a power bus anomaly in the spacecraft soon after launch. The spacecraft lost its Earth lock on 22 November 1989 and could not be put into safe mode due to a command receiver anomaly which had existed in the spacecrat since its launch.

INSAT-1D was launched on 12 June 1990 on board a Delta launcher from the United States of America and subsequently put into operational service.

INSAT-II TS

INSAT-II satellites are being indigenously fabricated to replace the INSAT-1 series of satellites, which were procured abroad. The INSAT-II space segment consists of three spacecraft, two of which are collocated. Each spacecraft will have about one and a half times the capacity of the INSAT-1 spacecraft; consequently, the INSAT-II satellites are heavier and more complex. The first INSAT-II test spacecraft (INSAT-IIA) is scheduled for launch by the end of 1991, and the second test spacecraft (INSAT-IIB) about a year thereafter, on board the European Ariane Launch vehicle.

During the past year, fabrication was completed on the structural model and electrical thermal model hardware of the INSAT-II test spacecraft, and assembly, integration and testing are currently in progress. Fabrication of the flight model components has also commenced.

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Augmented satellite launch vehicle

The augmented satellite launch vehicle (ASLV) is designed to provide a low cost operational vehicle to launch 150 kg class satellites into low Earth orbits and also to validate advanced technologies needed for the larger Indian launch vehicles such as PSLV. The first development flight in 1987 and the second in 1988 did not complete their missions.

In spite of this, the previous ASLV flights have provided valuable design inputs in the areas of strap-on technology, strap-on separation, inertial navigation technology, digital autopilot and closed loop guidance systems aero-structure and control interaction, trans-sonic buffeting, acoustic levels, S-band tracking, telemetry and command (TTC) technology, the metallic bulbous heat shields and an improved data base on aerodynamic coefficients, wind/gust effects and control requirements.

Preparations for the next developmental flight of ASLV (designated as ASLV-D3), which incorporates modifications based on the recommendations of the Experts Review Panel and the Failure Analysis Committee, are in progress with a view to carrying out the flight in 1991.

Stretched Rohini Satellite Series

Future satellites of the Stretched Rohini Satellite Series (SROSS), which are designed as payloads in ASLV launchers, are expected to carry out a number of scientific experiments in aeronomy provided by the National Physical Laboratory and the Physical Research Laboratory as well as astronomical experiments developed by the Indian Space Research Organisation (ISRO) and the Tata Institute of Fundamental Research in India.

Polar satellite launch vehicle

PSLV is designed to place 1,000 kg class remote-sensing satellites into 1,000-km Sun-synchronous polar orbits. PSLV, unlike all of its solid-stage predecessors, incorporates a liquid-propellant, second-stage motor and a liquid upper stage.

The most significant achievement during the past year was the successful static testing of the 125-ton first-stage motor (PS-1), the third largest in the world. Thus, qualification tests on all the four stages of PSLV have been completed.

Geosynchronous satellite launch vehicle

Configuration studies on the geosynchronous satellite launch vehicles (GSLV) capable of placing 2-ton class payloads in geosynchronous transfer orbit (GTO) are in progress. In addition to the use of existing or proven solid/liquid stages future GSLVs are planned to have a cryogenic upper stage for providing appropriate payload capacity in GTO.

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National Natural Resources Management System

The Department of Space is the nodal agency for the establishment of the National Natural Resources Management System (NNRMS) with the participation of central and state government agencies in India. A number of resource survey and monitoring projects were undertaken during the past year by NNRMS. Several steps have been taken towards making available remote-sensing data on a continued, assured basis for the various user agencies in the country.

Five regional remote-sensing service centres and a number of associate centres have been already set up in the country under NNRMS. Nineteen states in India have established state remote-sensing application centres to provide satellite-based remote-sensing application services.

Microwave remote-sensing programme

Design and development of C-band airborne synthetic aperture radar (SAR) has been undertaken. Establishment of a ground segment to receive and process the SAR data from ERS-1 is planned to familiarize the users with SAR data. Five application areas for SAR data have been identified, including soil moisture, geological exploration, monitoring of oil slicks, flood mapping and snow melt run-off. An X-band side-looking airborne radar (SLAR) has been made operational and aircraft flights were conducted during the year.

Space sciences

Several institutions in India pursued activities in space sciences, particularly in the field of the dynamics of solar carona, Halley's Comet particles, atmospheric pollutants such as sulphur dioxide, balloon-based experiments for the study of the middle atmosphere and trace gases, cosmic ray physics and the study of the magnetosphere. A national programme for geospher-biosphere related studies is also under development in co-operation with a number of institutions and scientists in India. ISRO also supported and funded a wide spectrum of research projects related to space in universities and space science/technology centres in select academic institutions.

International co-operation

As in the past, India continued its co-operation with several space agencies on a bilateral basis and also continued to contribute to the activities/programmes of international organizations, including the bodies and the specialized agencies of the United Nations in the fields of outer space. India pursues all its international co-operative activities in the spirit of, and in accordance with various international treaties evolved by the United Nations in the field of outer space.

In the spirit of promoting international co-operation and as a follow-up to the recommendations of the United Nations Conference on the exploration and Peaceful Uses of Outer Space (UNISPACE 82), India has continued to provide opportunities under a programme known as SHARES (Sharing of Experience in Space) to

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individuals from developing countries to provide hands-on experience in several fields of space applications. The programme provides support in terms of subsistence allowances, internal travel and free training. Fifty individuals from various developing nations have been provided assistance under the programme for periods ranging from two to six months.

India has also announced the availability of data from its IRS-1A satellites to interested countries. Details relating to the establishment of access facilities for IRS data have been provided to a number of countries.

India has also participated in the international efforts for satellite-aided search and rescue. A local user terminal and mission control centre were established in Bangalore, India, and they were declared operational as from 1 October 1989.

India has actively participated in international forums such as the International Astronautical Federation (IAF) and the Committee on Space Research (COSPAR), and has contributed actively to the activities of IAF's committees on liaison with international organizations and developing nations. Indian experts contributed in a special current events session on space and forest management organized by COSPAR during the 1990 IAF Congress held at Dresden, Germany.

For the purposes of spearheading applications-oriented research and the promotion of developmental and educational applications of space-based communications, a unique institution known as the Development and Education Communications Unit was evolved under ISRO several years ago. The Unit has not only been providing its services to national users but has also been training personnel from other countries. A three-week course on development communications was provided to Somalian officials.

At the bilateral level, ISRO pursued or explored co-operative activities with the Arabsat organization, Australia, Brazil, Canada, China and Japan. Under an existing co-operative agreement with the European Space Agency (ESA) arrangements for the reception and processing of data from ERS-1 are being negotiated. Several joint projects and exchanges of visits are being carried out in a co-operative arrangement between ISRO and the Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR) of Germany.* TTC support had been extended from the German Space Operations Centre station at Weilheim for the IRS-1A satellite. Arrangements for mutual TTC mission support for the future IRS series of satellites and the German/EUTELSAT mission were worked out. ISRO continued co-operation with the Centre Nationale d'Etudes Spatiales (CNES) of France under an existing agreement between the two agencies. The national Remote Sensing Agency in India receives, processes and

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* Through accession of the German Democratic Republic to the Federal Republic of Germany with effect from 3 October 1990, the two German States have united to form one sovereign State. As from the date of unification, the Federal Republic of Germany acts in the United Nations under the designation "Germany".

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distributes data of the SPOT satellite under a memorandum of understanding with SPOTIMAGE. The launch services for the initial INSAT-II satellites are procured from ARIANESPACE. ISRO has also co-operative arrangements with the Swedish Board of Space Activities to pursue activities of mutual interest. Training and education in the field of human settlement analysis is imparted by the Indian Institute of Remote Sensing in collaboration with the International Institute for Aerospace Survey and Earth Sciences (ITC) of the Netherlands. In co-operation with the Government of Mauritius, a tracking station was established in that country to support an IRS mission. Under the umbrella of the agreement signed with Glavcosmos of the USSR and the Academy of Sciences of the USSR Intercosmos Council, several activities are either being pursued or are under exploration. These include launch services for IRS satellites, atmospheric research through joint sounding rocket launches, Indian participation in the Soviet Mir space station and satellite-aided search and rescue efforts. The National Oceanic and Atmospheric Administration (NOAA) of the United States of America extended mission support for ISRO's tracking network. Under the aegis of a memorandum of understanding between India and the United States, the National Remote Sensing Agency of India continued to receive data from Landsat and NOAA satellites. India has also actively participated with and extended co-operation to international agencies such as the International Maritime Satellite Organization (INMARSAT), the International Civil Aviation Organization (ICAO), the Space Frequency Co-ordination Group (SFCG) and the Space Agency Forum for International Space Year (SAFISY).

As an initiative for International Space Year, an international co-operative mission known as PEACE (Protection of the Environment for Assuring a Cleaner Earth) involving the use of polar orbiting satellites for monitoring the Earth's environment was proposed to SAFISY members, several space agencies and other international organizations for their consideration.

Technology transfers spin-offs

Under its technology transfer scheme, ISRO continued to promote and support the commercialization of technologies developed in the Indian Space Programme for applications in various national sectors. The three major purposes served by this scheme comprise: (i) meeting the requirements of space programmes and projects through the buy-back of products produced by industry as a result of technology transfer; (ii) servicing the rapidly expanding space applications markets in India generated by the Space Programme in the areas of satellite communications, television and radio broadcasting, meteorological observations and remote sensing for natural resources survey and management; and (iii) exploiting the full potential of the indigenous technologies developed by the Space Programme for multifarious spin-off applications.

As of the end of December 1989, 163 distinct technologies had been licensed by ISRO and National Remote Sensing Agency. Of these, 7 were primarily for buy-back by the space applications market and 96 technologies served spin-off applications. Industry is playing an increasingly important role in various tasks related to the ongoing space projects.

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During 1989, 13 new product/process technologies were transferred by ISRO. Major technologies transferred included polymide resin for glass and carbon composites, polyamic acid, vinyl ester resin (VESTOR 40), the middle end image processing system, a 3-m diameter road-transportable/air-liftable antenna, an automatic microfiche camera, a photowrite system, a drum scanner digitizer, optics design software (Optosoft), a relay parameter tester, an 8-hp DC servomotor, etc. In addition, seven more technologies have been licensed to additional entrepreneurs to meet the growing market demand. About 100 products/processes and applications software packages are under development for technology transfer.

JAPAN

[Original: English]

1. Present activities

(1) Geostationary Meteorological Satellite (GMS)

The Japanese Geostationary Meteorological Satellite has played an important role in the Global Observation System (GOS), of the World Weather Watch (WWW) of the World Meteorological Organization (WMO) in conjunction with geostationary meteorological satellites launched by the United States, Europe and India as well as polar orbital meteorological satellites operated by the United States and the USSR.

GMS has provided meteorological services to over 20 countries and Territories in Asia and Oceania. The images received are utilized for various meteorological information services. Furthermore, GMS is serving to improve meteorological telecommunications in the collection of observation data from ships and remote areas/islands.

GMS-4 was launched in September 1989 as the successor to GMS-3.

(2) Marine Observation Satellite-1 (MOS-1 and MOS-1b)

MOS-1, Japan's first remote-sensing satellite, was launched in February 1987, and its orbit is Sun-synchronous at an altitude of approximately 900 km. The satellite's specific objectives are to observe marine phenomena such as the change in colour and temperature on the ocean's surface and to establish common technology for Earth observation satellites. Its image data are received directly by Thailand, Australia, Canada and ESA.

MOS-1b, the successor to MOS-1, has the same specifications as the latter. It was launched in February 1990.

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(3) X-ray astronomy satellite

The X-ray astronomy satellite Ginga was launched in February 1987. Shortly after its launch, the satellite made the first detection ever of the X-ray from the supernova SN1987A which appeared in the Large Magellanic Cloud for the first time in 400 years. In addition, Ginga has discovered new space X-ray sources and gamma ray bursters. Through these activities, Ginga has attracted a great deal of attention and high expectations among astronomers world wide.

On board Ginga are instruments which Japan developed in co-operation with the United Kingdom and the United States. This has contributed significantly to the promotion of international collaboration in the field of space science.

(4) Aurora observation satellite (EXOS-D)

The aurora observation satellite "akebono", or EXOS-D, was launched in February 1989. It observes the acceleration mechanism of particles and aurora phenomena in the geomagnetic region at high resolution. The orbit is highly elliptic, with an approximate perigee of 270 km and apogee of 10,000 km. On board EXOS-D is a suprathermal ion spectrometer developed by the National Research Council of Canada. The Prince Albert Tracking Station in Canada is carrying out the telemetry operation of the satellite.

(5) Thirteenth scientific satellite (MUSES-A)

The MUSES-A was launched in January 1990. This satellite carries out lunar swingby operations as well as the precise orbital determination control and high-efficiency transmissions required for future interplanetary missions.

On board the satellite is a dust counter developed by the Munich Institute of Technology in Germany. In addition, the MUSES-A has the support of the Jet Propulsion Laboratory of the National Aeronautics and Space Administration (NASA) of the United States in its mission operation phase.

MUSES-A successfully carried out its first and second lunar swingby operations in March and July 1990 respectively.

2. Future activities

(1) GMS-5

In 1994 GMS-5 is scheduled to be launched as the successor to GMS-4 to ensure the continuous support of the meteorological services in Asia and Oceania. The satellite will have an infrared water vapour channel to detect mid-atmospheric conditions and two infrared window channels which are expected to provide more precise detection of sea surface temperature.

The GMS-5 is also planned to be equipped with the search and rescue transponder to relay distress signals for demonstration experiments.

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(2) Earth Resources Satellite-1 (ERS-1)

ERS-1 is an Earth observation satellite scheduled to be launched in 1992; its orbit will be Sun-synchronous at an altitude of approximately 570 km. The main objective of the satellite is to explore resources. In addition, it will conduct a variety of operations, such as monitoring polar/sea ice, taking national land surveys and making agriculture/forestry/fishery-related observations. To accomplish such missions, the satellite will be equipped with a synthetic aperture radar and an optical sensor.

(3) Advanced Earth Observation Satellite (ADEOS)

In order to contribute to the solution of global climatic change issues, ADEOS is planned to be launched approximately in 1995 to conduct various monitoring activities from space, such as monitoring of sea surface colour and temperature and distribution of ozone and carbon dioxide.

ADEOS will carry eight instruments, three of which will be supplied by foreign suppliers in response to Japan's announcement of opportunity (AO).

(4) First materials processing test (FUWATTO '91)

The FUWATTO '91 programme is the experimental scheme in which a Japanese payload specialist will for the first time board the United States Space Shuttle and conduct new materials, processing tests in space. The Space Shuttle mission for FUWATTO '91 is currently scheduled for 1991.

(5) International Microgravity Laboratory (IML)

Japan will take part in the United States IML-1 and IML-2 programmes, which will comprise an international microgravity experimental scheme using the Space Shuttle for the accumulation of space environment utilization technology. IML-1 is scheduled to be launched in 1990; IML-2, in 1993.

(6) Space station

The permanently manned space station will be constructed in a low Earth orbit through co-operation between Japan, the United States, Europe and Canada. In September 1988, Japan, together with the United States, member countries of the European Space Agency (ESA) and Canada, signed the Space Station Co-operation Agreement, and in September 1989, Japan deposited its instrument of acceptance. Under the Agreement, Japan has been undertaking the development of the Japanese Experiment module (JEM), which will be launched by the Space Shuttle in Japanese fiscal year 1997. In JEM materials processing experiments, life science experiments, etc., will be performed.

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(7) Space Experiment by Particle Accelerators (SEPAC)

SEPAC will be launched by the Space Shuttle in 1990. This represents the second launch of SEPAC. It aims to clarify the mechanism of aurora emission, the dynamics of charged particles and electromagnetic wave excitation in geomagnetic plasma by radiating plasma and electron beams.

(8) Fourteenth scientific satellite (SOLAR-A)

SOLAR-A is scheduled to be launched in 1991. The objective of the satellite is to obtain high-resolution images of solar flares during the next solar maximum period. Its designed orbit is quasi-circular, with an altitude of 550-600 km.

On board the satellite are a soft X-ray imager, which was jointly developed by the Institute of Space and Astronautical Science of Japan (ISAS) and the Lockheed Palo Alto Institute, and the X-ray High-Resolution Spectrometer, which was jointly developed by ISAS, the Mallard Space Science Institute of London University and the Rutherford-Appleton Laboratory, United Kingdom.

(9) Earth Magnetosphere Observation Satellite (GEOTAIL)

GEOTAIL is scheduled to be launched in 1992. It is essentially a collaborative mission between ISAS and NASA. ISAS is in charge of the development of the spacecraft, and NASA is responsible for the launch of the spacecraft by a Delta II rocket. The satellite will investigate the structure and dynamics of the long-extending magnetotail on the dark side of the Earth.

(10) X-ray Astronomical Satellite (ASTRO-D)

ASTRO-D is scheduled to be launched in 1993. Its main objective is the X-ray imaging of a variety of celestial bodies as well as the precise observation of the spectrum in the X-ray band. The orbit will be quasi-circular with an altitude of 500-600 km.

On board the satellite will be an X-ray reflector and X-ray imager to be developed by ISAS, the NASA Goddard Space Flight Center and the Massachusetts Institute of Technology, United States.

(11) Tropical Rainfall Measuring Mission (TRMM)

In order to address the problem of global climatic change, TRMM is planned to be launched around 1996 as a Japan-United States joint programme to monitor tropical rainfall from space.

Japan will provide the precipitation radar and launch TRMM with an H-II launch vehicle. The United States will provide the spacecraft and other sensors.

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(12) Sixteenth scientific satellite (MUSES-B)

MUSES-B is scheduled to be launched in 1995. The satellite is intended to verify the launch performance of a new launch vehicle now under development by ISAS and will observe distant celestial objects with high resolution using very long baseline interferometry (VLBI) techniques in combination with large antennae on the ground.

NETHERLANDS

[Original: English]

International activities

The Netherlands spends approximately 150 million guilders a year on European Space Agency (ESA) programmes, participating in all major ESA activities relating to infrastructure (Ariane-5 launcher, Columbus space station and Hermes space plane), space science and user programmes (Earth observation, telecommunications, microgravity research).

National activities

The Netherlands has a small-scale national space programme. Its budget for 1990 is approximately f. 40 million. The major part of this amount is intended to stimulate research, enabling Dutch firms to improve their technological and scientific capacity and compete more successfully for ESA contracts. Many of the projects are directly linked to ESA programmes.

The Netherlands attaches great importance to the conservation of nature and the environment. Therefore it not only participates in ESA's remote-sensing programmes but also has a national remote sensing programme. A major follow-up programme has recently been announced.

Finally, the Netherlands is collaborating with Italy on the production of an astronomical satellite, known as SAX.

PAKISTAN

[Original: English]

1. Introduction

1.1. Pakistan's space programme reflects the country's commitment to the peaceful uses of outer space. The programme is aimed at furthering research in space science and allied fields, developing indigenous capabilities in space technology and promoting the applications of space science and technology for the socio-economic uplift of the country. The Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) is the national space agency responsible for the execution of the space science and technology programmes in the country.

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1.2. In pursuit of these objectives, SUPARCO is actively engaged in a broad-based research and applications programme covering many important fields of space science and technology. The principal research-and-development projects being carried out are:

- Establishment and operation of satellite ground stations for: (a) acquisition of data for Earth resources and environmental surveying and for atmospheric/meteorological studies; (b) transmitting and receiving communications signals, including TV transmissions; (c) scientific experiments; and (d) specific applications, such as collection of data through satellites from unmanned remote data collection platforms and reception of signals relating to the satellite-aided search-and-rescue (COSPAS-SARSAT) programme;

- Development of necessary facilities for designing, assembly/fabrication and launching of: (a) light-weight satellites in near-Earth orbit for various scientific and applications purposes, and (b) communication satellites in geosynchronous orbit;

- Conduct of studies in various fields of space and atmospheric sciences, including satellite meteorology, satellite radiance studies, satellite geodesy, atmospheric pollution and astronomy;

- Conduct of studies based on the application of satellite/aerial remote-sensing data to environmental monitoring and natural resources surveying in agriculture, forestry, water resources, geology, geography, land use, etc.;

- Conduct of research studies relating to the ionosphere and associated radio-wave propagation and geomagnetism;

- Establishment and operation of facilities for the tracking of satellites/rockets to determine their orbital parameters and trajectories;

- Development of the necessary instrumentation for various scientific experiments;

- Development of software to support the above scientific and technological programmes.

2. Research and applications programmes

Satellite ground station

2.1. SUPARCO has been actively involved in a multidisciplinary satellite remote-sensing applications programme since 1973 that has continued to expand with the passage of time. A host of other organizations/agencies in the country besides SUPARCO have also made use of satellite remote sensing (SRS) data in varying degrees for various applications. By the early 1980s it was felt that

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remote-sensing applications activity in Pakistan had expanded sufficiently to warrant the establishment of data acquisition facilities within the country to provide data in real time/near real time to national user agencies. SUPARCO has accordingly established a ground receiving station near the federal capital, Islamabad, for the acquisition of data from the Landsat multispectral scanner (MSS) and thematic mapper (TM); SPOT, for high-resolution visible (HRV) multispectral (XS) and panchromatic (PAN); and advanced very-high-resolution radiometer (AVHRR) high-resolution picture transmission (HRPT) data from the National Oceanic and Atmospheric Administration (NOAA) of the United States of America. The Station was formally inaugurated by the Prime Minister of Pakistan on 17 August 1989. It is expected to give a significant boost to remote-sensing applications in Pakistan.

2.2. The satellite ground station (SGS) has three subsystems, all installed at the same site. The Data Acquisition Sub-system consists of: (i) an S- and X-band 10-metre-diameter Cassegrain dish antenna for SPOT and Landsat data reception; (ii) an L-band antenna for NOAA data reception; and (iii) two high-density tape recorders for recording, satellite telemetry and reading data for inventory or production of corrected images. The station, which is one of the most advanced and sophisticated stations in the region of Asia and the Pacific, is being managed and operated entirely by Pakistani scientists, engineers and technicians.

2.3. During the last 15 months of its operation, the Islamabad Station for the Landsat, SPOT and NOAA series of satellites acquired approximately 9,500 Landsat TM scenes, 5,300 Landsat MSS scenes, 3,000 SPOT XS scenes and 3,000 SPOT PAN scenes, from which about 1,400 computer-compatible tapes (CCTs), 1,160 black-and-white and colour films and 1,200 black-and-white and colour prints at various scales were generated for various user agencies or for use within SUPARCO. By the end of 1989 SGS has completed coverage of the whole of Pakistan approximately four times through Landsat TM, three times through Landsat MSS and once through SPOT (XS) and SPOT (PAN) data.

Remote-sensing applications

2.4. SUPARCO has been actively engaged in a multidisciplinary remote-sensing applications programme since 1973, and established a full-fledged National Remote Sensing Applications Centre, known as RESACENT, in 1978. The Remote Sensing Applications Division and the Agricultural and Land-use Studies Division which work at RESACENT are engaged in the conduct of research studies based on the application of SRS data to various Earth resources and environmental problems covering a wide range of Earth sciences. SUPARCO is also the national co-ordinator for remote-sensing activities and has played a pioneering role in promoting the use of this technology in Pakistan. As the national co-ordinator, SUPARCO acquires and archives SRS data of the country, disseminates the data to national user agencies on request, provides technical assistance to these agencies in the application of the data, conducts collaborative research projects with user agencies if required and organizes training courses, workshops and seminars for their benefit.

2.5. In addition to the main centre, RESACENT, at Karachi, regional remote-sensing centres have been established in other major cities of Pakistan to provide users in

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different parts of the country with quick and convenient access to data and basic interpretation facilities. Such centres have already been established at Islamabad and Peshawar. A third regional centre will be set up at Lahore, to be followed by a fourth at Quetta.

Data interpretation facilities

2.6. RESACENT has adequate facilities for visual and digital analysis of remote-sensing data. Electro-optical equipment used for visual interpretation includes the density slicer, colour additive viewer, zoom transferscope, zoom stereoscope, densitometer, ratioing radiometer, diazo printer/developer and other miscellaneous equipment. The Centre also has a well-equipped photographic laboratory. Digital processing facilities include a dedicated, interactive, microprocessor-based digital image processing system known as EBBA II. The image processor is hooked up to an IBM PCAT with various peripherals, such as a 1,600-bpi tape drive unit, colour copier, digitizer and a colour display monitor of 512 x 512 resolution. Two sophisticated image analysis software packages are being used with this system. To enhance the image processing and general digital computer facilities at RESACENT, a MicroVAX II computer and a GPX II workstation were acquired by the Remote Sensing Applications Division in August 1989. A local area network incorporating eight user terminals and the GPX II workstation is being developed around the MicroVAX II. This system has basically been configured to process the increased inflow of SRS data being generated at SGS.

Data archives

2.7. RESACENT's data archives contain over 2,500 Landsat MSS scenes in the form of transparencies and about 250 Landsat MSS CCTs, acquired from various foreign ground receiving stations/data distribution centres and more recently from the SUPARCO SGS. The MSS data archived at the Centre represent roughly 40 times' repetitive coverage of the entire country from 1972 to date. A sizeable amount of SPOT data have also been procured from SPOT IMAGE. The data archives are being constantly expanded with the addition of Landsat TM, SPOT XS/PAN and NOAA AVHRR HRPT data acquired by SGS. A limited amount of Landsat return-beam vidicon (RBV), Metric Camera, Shuttle Imaging Radar-A (SIR-A) and NIMBUS 7 coastal zone colour scanner (CZCS) data are also available at RESACENT.

Application studies

2.8. The following major studies have been carried out so far at RESACENT and other regional centres:

- Mapping of forests in hilly areas;
- Glacier mapping in the northern areas of Pakistan;
- Desertification monitoring;
- Turbidity and siltation in dam reservoirs;

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- Application of SPOT Data for land-use/land-cover studies;
- Application of NOAA HRPT data to environmental studies;
- Geomorphic analysis and mapping of tidal landforms in the Kalmat Lagoon;
- Classification of waterlogging/salinity;
- Wetland changes;
- Mangrove forest mapping;
- Flood inundation studies;
- Mapping river course changes;
- Land degradation in the Cholistan Desert;
- Application of NOAA HRPT data to environmental studies;
- Irrigation suitability land classification;
- Identification of land surface features in desert areas;
- Mapping and surface cover classification;
- Geological analysis through Landsat RBV and metric camera imagery;
- Comparison of data from different sensors for urban land-use studies;
- Assessing the potential of satellite data for population surveying.

Remote-sensing operations

2.9. The Remote Sensing Operations Division has been set up to provide support to the Remote Sensing Applications Division in the operational aspects of the remote-sensing programme. The Division is principally concerned with the development and expansion of in-house capabilities in SUPARCO for acquisition of aerial remote-sensing data for various resource and environmental studies to supplement the satellite remote-sensing applications programme. SUPARCO is examining the feasibility of acquiring a light aircraft of its own, to be fitted with different types of sensors, procured or developed in-house, for aerial remote sensing. The Division is engaged in studying technical literature on different types of available aircraft. A thorough technical evaluation of different aircraft and their compatibility with various types of remote sensors and data acquisition systems will be made, keeping in view the requirements of SUPARCO and other national user agencies.

2.10. SUPARCO possesses sophisticated cameras for aerial photography. In addition to the four-band I^2S Multispectral Camera, which has been flown on several aerial missions, an assembly of four Hasselblad ELX 500 Cameras, complete with necessary accessories, has also been procured. The various filters procured with the cameras correspond to the four bands of the Landsat MSS and the three bands of the SPOT HRV (XS) sensors. Other sophisticated cameras, scanners and radar imaging devices will be procured in the coming years.

Space communications

2.11. SUPARCO's long-term programme in the field of satellite communications is aimed at the development of the necessary infrastructure for the development and optimal utilization of space telecommunications and space technology in the country. The main activities of the Satellite Communication Division and the Satellite Development Division include design and development of low-cost, low Earth orbit spacecraft. The Satellite Communication Division is also engaged in installation, operation and maintenance of ground receiving stations for tracking and reception of low Earth orbit as well as geostationary satellites, establishment of a local user terminal and mission control centre for the Satellite-aided Search and Rescue (COSPAS-SARSAT) Programme, installation, operation and maintenance of small Earth terminals, such as SCPC (single channel per carrier) terminals and VSATs (very small aperature terminals) for satellite communication and development of related software. These activities are aimed at the development of necessary infrastructure for the eventual implementation of a national domestic communication satellite system.

Pakistan's first low-cost experimental satellite, BADR-1

2.12. Pakistan's first low-cost experimental satellite, known as BADR-1 ("badr" means "full moon") has been indigenously designed and fabricated as a first step in the long-term plan of the country for the development of low-cost scientific satellites for experimentation in different fields of space science and technology. The main objectives of the BADR-1 Project are: to acquire know-how for the indigenous development of satellites; to create the infrastructure for future satellite development activities; to test the performance of indigenously developed satellite subsystems in a space environment; to perform experiments in real-time voice and data communications between two user ground stations; to demonstrate store-and-forward type message communication; to educate the country's academic, scientific and amateur community in the tracking and use of low Earth orbiting satellites.

The salient features of the Satellite are:

Configuration:	26-sided polyhedron sphere 19 in. (483 mm) in diameter
Weight:	50 kg
DC Power:	5 W (conditioned power)
Frequencies (Uplink):	435.030 MHz, 435.512 MHz
(Downlink):	144.028 MHz, 145.825 MHz

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RF Power Radiated:	**1 Watt (1 000 mw); omnidirectional**
Orbit:	
Perigee	210 km
Apogee	992 km
Inclination	28.5 deg
Period	96.5 min
Anticipated In-Orbit Life:	5-6 months

2.13. The satellite was launched from a Chinese Long March 2E (LM-2E) launch vehicle on 16 July 1990 from Xichang Satellite Launch Centre, China. Its payload includes telemetry and command equipment and a digital communication experiment to establish links with various satellite Earth stations all over the world. The satellite has been tracked by the SUPARCO tracking stations at Karachi and Lahore. BADR-1 has succeeded in delivering valuable data on the performance of the spacecraft in actual space environment and had completed more than 500 orbits around the Earth up to 20 August 1990, when contact with the satellite was broken. These data relate to the stability of the satellite orbit, the functioning of the power supply and telemetry subsystems as well as to the response of the spacecraft to ground commands. The reasons for the loss of signals are being investigated and efforts are continuing to re-establish contact. The operations of the spacecraft have been concentrated on acquisition of several parameters, including temperatures inside as well as outside the spacecraft, current, voltages and a number of status points to facilitate processing and interpretation of telemetry data received during the satellite's passes over Pakistan. Besides the data on the functioning of the back-up power system during both sunlit passes and those over the dark side on the Earth, BADR-1 has been successfully tested to acknowledge various commands sent by SUPARCO's ground station at Karachi.

2.14. SUPARCO scientists/engineers are currently involved in the system definition study of Pakistan's second experimental satellite, designated BADR-B, and performance characteristics of its subsystems and the payload elements are being identified.

COSPAS-SARSAT Satellite-aided search-and-rescue programme

2.15. The COSPAS-SARSAT programme facilitates detection and location of distress signals through the use of low Earth orbiting satellites. The main feature of the satellite-based system is its repetitive, global coverage. Since the satellites circle the Earth approximately every 100 minutes, the waiting time between the activation of a distress transmitter and its detection by a satellite is short. At the latitudes covering Pakistan and for a constellation of four satellites, the mean waiting time between a distress signal and its reception by a satellite is approximately one hour. The 121.5 MHz, 243 MHz and 406 KHz signals emitted by either an emergency locator transmitter or an emergency position indicating radio beacon, after being detected by a polar orbiting spacecraft, are relayed to the nearest dedicated ground stations, called local user terminals (LUTs), where the

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location of the emergency transmitter is determined by measuring the Doppler shift caused by the relative movement of satellite and the distress beacons. All satellite data received and processed by the LUT are than relayed to a mission control centre (MCC), which alerts the appropriate rescue co-ordination centre. The rescue co-ordination centre immediately initiates the actual search-and-rescue operation in accordance with conventional practice. SUPARCO has installed such a system, inclusive of LUT and MCC, at Lahore.

2.16. Pakistan's participation in the COSPAS-SARSAT programme will lead to the creation of a national co-ordinated search-and-rescue network entailing the following benefits for efficient search-and-rescue operations:

(a) An early indication of a possible air crash or marine accident by simply receiving a distress signal;

(b) Detection and location of distress beacons, thus avoiding grid searches by aircraft which are time-consuming and highly expensive;

(c) Safety of the personnel involved in search and rescue from unnecessary risks by accurate location of the distress signals;

(d) Prompt detection of distress signals within approximately an hour, due to the network of five operational satellites.

2.17. Main users of the COSPAS-SARSAT system in Pakistan include the Civil Aviation Authority, Maritime Security Agency, Pakistan Coast Guards and Ministry of Communication (Ports and Shipping Wing). They will primarily be responsible for co-ordinating rescue activities within the country. The services, however, can also be extended to many other departments within Pakistan, such as the Oil and Gas Development Corporation, the Tourism Development Corporation, the Wild Life and Forest Department and the Survey of Pakistan as well as to agencies outside Pakistan.

Space science and atmospheric research

2.18. Space science and neutral atmospheric research is one of SUPARCO's earliest research activities dating back to the early 1960s. SUPARCO's Space Science Division is now involved in diversified fields relating to space science and atmospheric research, including satellite radiance studies, atmospheric pollution measurement studies using ground-based equipment, satellite meteorology based on the use of NOAA automatic picture transmission APT images, satellite geodesy, optical tracking of satellites, astronomy and use of satellites for collection of meteorological, hydrological and environmental data from unattended remote data collection platforms (DCPs).

Satellite meteorology

2.19. The APT station installed at SUPARCO's Space and Atmospheric Research Centre (SPARCENT) in April 1988 is being operated round-the-clock. The station has advanced capabilities for processing of APT images including zooming, density slicing, animation latitudinal/longitudinal grid generation and colour enhancement,

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and is acquiring APT data from the NOAA-9, NOAA-10 and NOAA-11 satellites in the visible and infra-red channels. NOAA APT images are used to study weather patterns, with special reference to the summer monsoons, as well as other related environmental phenomena. It has been observed that, although NOAA APT data have a coarse spatial resolution of 4 km, they can still provide information useful not only for meteorological studies but also for environmental and even resource studies on a regional scale. A study was also conducted using the APT data to estimate the sea surface temperature in the exclusive economic zone of Pakistan.

Atmospheric studies from satellite radiance data

2.20. A ground receiving station for the real time reception and processing of TIROS Operational Vertical Sounder (TOVS) HRPT data from the polar orbiting NOAA satellites is planned to be set up in SUPARCO to enable atmospheric radiance studies and associated meteorological forecasts to be carried out operationally. The station will consist of a tracking antenna, RF receiver, bit synchronizer, format synchronizer, HRPT processor, graphics display, tape drive, dish antenna (121 MB), processor, printer and plotter and TOVS processing software. The station will be capable of collecting various types of atmospheric and meteorological data and will allow simultaneous interactive analysis and a combination of meteorological information from all sources such as satellites, radiosondes, etc., for research studies as well as for short- and long-term weather forecasting.

Establishment of the ARGOS network in Pakistan

2.21. SUPARCO has set up the ARGOS facilities in Pakistan. The prime objective of the ARGOS system is the collection of meteorological, hydrological and environmental data by unmanned DCPs installed in remote or inaccessible areas and the acquisition of these data through satellite at conveniently located user terminals. The data collected by the DCPs and relayed by satellite could pertain to a wide range of parameters, such as the physical, chemical or biological properties of the solid Earth, the Earth's hydrosphere (rivers, lakes, oceans) or the atmosphere.

2.22. During the first phase of the project, seven DCPs have been set up on the land at widely scattered and mostly remote locations in the country to measure various environmental parameters. Another three DCPs will be deployed in the sea: two on moored buoys and one as a mobile station on a ship. The first phase of the project has the following broad objectives:

(a) Collection of meteorological data from remote and inaccessible areas for improved weather forecasting;

(b) Development of a snowmelt run-off monitoring system to improve accuracy of river run-off and flood forecasting for better management of reservoirs, irrigation systems, power generation and flood protection measures;

(c) Measurement of sea surface temperature, sea currents, tide heights, chlorophyll and marine pollution for improved study of oceanographic/marine processes, more effective exploitation of ocean resources and better management of ports;

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(d) Location-facility for monitoring the movement of ships;

(e) Use as a supplementary source of information in resource/environmental studies based on satellite remote-sensing data.

2.23. The meteorological, hydrological, environmental and oceanographic data to be acquired through the ARGOS network established by SUPARCO will also be provided to other national organizations, such as the Water and Power Development Authority, the Pakistan Meteorological Department, Port Qasim Authority, National Institute of Oceanography, Pakistan National Shipping Corporation, etc., which require such data on a timely basis.

Position mapping from satellites

2.24. Two mobile satellite ground receiving instruments (Geoceivers) capable of receiving signals from the US TRANSIT satellites are being employed by SUPARCO for the purpose of position mapping. These Geoceivers have been used for surveying at several locations in both the southern and northern parts of the country. The Geoceivers have also been used to determine the precise geocentric co-ordinates of the locations of the antennae at the SGS near Islamabad and the LUT for COSPAS-SARSAT at Lahore. There are also plans to purchase the receivers which use the US NAVSTAR (Navigation Satellite Time and Ranging) Global Positioning System (GPS). When fully deployed in the early 1990s, the satellite segment will consist of a constellation of 18 operational satellites plus 2 in-orbit spares. Appropriate receivers track the codes or the phase of the carriers (or both). If ranges of four satellites are combined with the orbit description, the receiver determines its three-dimensional geocentric co-ordinates.

Atmospheric pollution monitoring studies

2.25. SUPARCO's atmospheric pollution studies were initiated in 1984 with the measurement of surface ozone concentration and suspended particulate matter. This work was later extended to include continuous monitoring of oxides of nitrogen, sulphur and carbon and inhalable fractions of suspended particulate matter at different locations in the metropolitan area of Karachi, the country's largest city. Air pollution monitoring activities have also been recently extended to Lahore, the second-largest city in the country.

Optical tracking of satellites

2.26. A mobile video optical system (MVOS) consisting of a telescope, image intensifier, etc., has been established at Lahore and is being used for tracking the passage of different sunlit Earth orbiting satellites from Pakistan. Suitable software for tracking of satellites is available in Microsoft Basic which can be used on an IBM PC AT. The programme displays tracking co-ordinates for up to eight satellites on the screen at one time and updates them continuously in real time.

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Astronomical studies

2.27. An astronomical observatory has been established by SUPARCO at Lahore. At present a 14-inch Cassegrain optical telescope is being used at the observatory for the study of celestial bodies, eclipses of the moon and the Sun, clusters of stars, nebulae, galaxies, etc. Recently a study was undertaken on the appearance and formation of sunspots and their effect on various terrestrial phenomena. The results of the study have demonstrated that the cause of the appearance and decay of the sunspots in an 11-year cycle is the differential rotation of the Sun. The equipment has also been used to study the various features on the surface of the moon.

Ionospheric research and radio-wave propagation

2.28. SUPARCO has been actively involved in ionospheric research studies since the mid-1960s and has accumulated and analysed a vast amount of data on ionospheric conditions over Pakistan. The Ionospheric Research Division continues to be actively engaged in studying the local ionosphere and the various ionospheric phenomena affecting short-wave radio propagation conditions. The Division operates a chain of three vertical ionospheric sounders, one each at Karachi, Islamabad and Multan, which provide data on a variety of ionospheric parameters. The sounder at Karachi is digital, while the other two sounders at Multan and Islamabad are analog. The Division is also equipped with VLF receiver/comparator for monitoring standard VLF transmissions between Rugby/Criggion, England, and Karachi to detect sudden phase anomalies which are indicative of solar flares. The Division has an Automatic Magnetic Observatory System (AMOS-III) at Karachi for measuring and recording geomagnetic data which are used in various related studies. It has extensive in-house computer facilities for processing the data obtained from the digital sounder and AMOS-III and for computing the maximum usable frequency/frequency of optimum transmission (MUF/FOT) predictions. Bulletins containing MUF/FOT predictions and geomagnetic data are regularly issued to various ionospheric data users in the country.

Computer support

2.29. The Computer Centre established by SUPARCO provides computer hardware and software support to SUPARCO's scientific and technological programmes as well as administrative work. It also plays a co-ordinating role in the evaluation, selection, procurement, installation and maintenance of computer systems in various establishments of SUPARCO. The Centre is engaged in the following activities:

- Development work of real-time data-processing systems;
- General-purpose computation for electronic circuit design, rocket trajectory evaluation, radar data processing, satellite data processing, aerodynamic studies, simulation studies, ionospheric and tropospheric data processing, finite element analysis, CAD/CAM and mathematical modelling;

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- Computerization of administrative activities of SUPARCO, which includes inventory accounting, payroll, personnel management system, library management system, supply and procurement system, financial accounting, budget preparation and monitoring system and management information system;

- Computer-aided drafting, word processing, etc.

Computer hardware facilities at the Centre include:

- MicroVAXs for real-time data-processing system;

- VAX 11/780 with graphic work station for scientific computational work;

- IBM 4361 for administrative/management applications;

- Several personal computers for CAD and word processing.

2.30. The Centre is also equipped with a network by which both VAX and IBM computers can be accessed with file transfer facility on PC, which is very useful in transferring data from one system to another when required.

Space-related activities in other national organizations

Meteorology

2.31. The Pakistan Meteorological Department operates four NOAA APT Stations at Karachi, Lahore, Islamabad and Peshawar respectively. The NOAA images are used to study cloud patterns and movements. The Department also collects data on various meteorological parameters at different heights in the atmosphere with the help of radiosondes/balloons. The NOAA images and radiosonde/balloon data are studied in conjunction with conventional ground-based meteorological measurements for routine weather forecasting. The NOAA APT images acquired by the Meteorological Department are shown in the daily weather reports on Pakistan Television.

Flood forecasting

2.32. The flood Forecasting and Warning Centre, at Lahore, operated by the Pakistan Meteorological Department, uses NOAA images and rainfall data obtained by precipitation-measuring radars located at Sialkot and Lahore in conjunction with hydrological and meteorological data acquired by a chain of data collection stations spread over the catchment area of the upper Indus basin for flood forecasting and warning, especially during the flood season in the monsoon and post-monsoon periods.

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Telecommunications

2.33. Pakistan Telegraph and Telephone Department has been operating a satellite Earth station since 1974 at Deh Mandro, about 50 kilometres north of Karachi. The station provides a 24-hour direct telecommunication link through the International Telecommunications Satellite Organization (INTELSAT) system between Pakistan and the other countries of the world.

2.34. Another satellite Earth station linked to the INTELSAT system was commissioned by the Pakistan Telephone and Telegraph Department at Islamabad in 1987. With two stations operating in the country, circuit availability for Pakistan's telecommunications needs have increased substantially.

Remote-sensing applications

2.35. Satellite remote-sensing data provided by SUPARCO have been used by about 60 other user departments/organizations in Pakistan for a wide variety of applications in the fields of agriculture, water resources, land-use, forestry, geology, geography, soil science, oceanography, cartography, etc. The Water and Power Development Authority has used Landsat data for studying water-logging and salinity, dam monitoring, snow surveying, hydro-geological investigations and other water resources studies.

Astronomy

2.36. The University of Karachi has an astronomical observatory equipped with a 6-inch Coude reflection type telescope. The University of the Punjab, Lahore, also has an astronomical observatory which is equipped with a reflecting telescope. These observatories are engaged in observing, photographing and studying the moon, lunar and solar eclipses, comets, planets, stars, galaxies and other celestial bodies. The Quaid-e-Azam University, Islamabad, is engaged in theoretical studies in astronomy and astrophysics. Pakistan International Airlines has set up two planetariums, one each at Karachi and Lahore, for the education and entertainment of the general public, particularly the youth.

3. Training, seminars/workshops and conferences

Local training programmes and seminars/workshops sponsored or co-sponsored by SUPARCO

3.1. In-house orientation courses covering a wide range of subjects related to space science and technology for various groups of newly recruited scientists and engineers are conducted on a regular basis by SUPARCO. In addition, short training courses are arranged on a six-month basis to acquaint the national users with satellite remote-sensing data and its analysis and interpretation for applications in the disciplines of agriculture, forestry, geology, hydrology, cartography,

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etc.* In addition, the following courses, seminars and workshops were sponsored or co-sponsored by SUPARCO during the period July 1988 to July 1990:

(a) SUPARCO and the Scientific and Cultural Society of Pakistan conducted a five-week course on computers at the University of Karachi in July-August 1988. A total of 233 students attended the course;

(b) SUPARCO and the Centre of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore, organized a two-week training course on remote-sensing applications to water resources surveying at Lahore in October 1988. A large number of personnel from different user agencies attended the course. Four SUPARCO scientists/engineers delivered lectures at the course;

(c) A short training course on remote-sensing applications was organized at SUPARCO's Space Applications and Research Centre (SPARC), at Peshawar, from 26 to 30 March 1989. The training course comprised lectures/presentations/discussions, workshop sessions and a field survey. It was attended by 36 professional scientists/engineers from various federal and provincial user departments. Five SUPARCO scientists/engineers delivered lectures and conducted the workshop sessions;

(d) The Amateur Astronomical Society of Pakistan (AMASTROPAK) and SUPARCO organized a three-day national symposium on SUPERNOVA-SHELTON at Karachi from 3 to 5 April 1989;

(e) A workshop on oceanographic/marine space information systems was co-sponsored and hosted by the Government of Pakistan/SUPARCO, in co-operation with the United Nations Outer Space Affairs Division, the Indian Ocean Marine Affairs Co-operation (IOMAC) and the United Nations Development Programme (UNDP) at Karachi from 2 to 6 July 1989. The main objective of the workshop was to analyse the role of space information systems in the assessment and management of marine and coastal resources and in monitoring the environment of the Indian Ocean region. The workshop was attended by a total of 72 participants/speakers/experts, of which 25 came from 18 developing countries (other than Pakistan) of the Indian Ocean region, namely, Bangladesh, Bahrain, Comoros, Ethiopia, Indonesia, Iraq, Islamic Republic of Iran, Kenya, Kuwait, Madagascar, Malaysia, Oman, Qatar, Somalia, Sri Lanka, Thailand, Uganda and the United Republic of Tanzania, and 11 speakers/experts were from the developed countries of the United States and the Union of Soviet Socialist Republics, and such international agencies as the Outer Space Affairs Division of the United Nations, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO), the European Space Agency/European Space Research Institute (ESA/ESRIN), the International Maritime

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* For detailed information, see the Directory on Education, Training, Research and Fellowship Opportunities in Space Science and Technology and its Applications (A/AC.105/366 and Add.1 and A/AC.105/432).

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Satellite Organization (INMARSAT), NOAA, etc., while 36 participants were from Pakistan, representing various government/semi-government departments and autonomous bodies. A paper entitled "Gaining access to space information systems: opportunities and problems" was presented by a Chief Scientific Officer of SUPARCO;

(f) A symposium on remote-sensing applications for resource development and environmental management was jointly organized by the Regional Remote Sensing Programme (RRSP) of the Economic and Social Commission for Asia and the Pacific (ESCAP), UNDP and SUPARCO at Karachi from 23 to 26 July 1989. The objective of the symposium was to promote the exchange of views and experiences among scientists in the ESCAP region in the use of remote-sensing techniques for resource development and environmental management and to foster mutual understanding between different user groups in enhancing the region's capabilities in the application of remote-sensing technology through co-operative activities. A total of 52 participants attended the symposium, of which 12 were from 12 developing countries (other than Pakistan) of the region, namely, Bangladesh, China, India, Indonesia, Islamic Republic of Iran, Malaysia, Nepal, Republic of Korea, Singapore, Sri Lanka, Thailand and Viet Nam, and 40 were from Pakistan, belonging to various government, semi-government and autonomous bodies. Two experts attended from France and one each from FAO and ESCAP RRSP;

(g) A short training course on applications of remote sensing to land use and agricultural statistics was organized by SUPARCO, at the request of the Federal Bureau of Statistics (FBS), Government of Pakistan, at Islamabad from 30 August to 5 September 1989. Twenty-one FBS officials and six officials of the United States Department of Agriculture (USDA)/United States Agency for International Development (USAID) serving as consultants to FBS attended the course. Six SUPARCO scientists/engineers delivered lectures and conducted the workshop sessions.

Foreign training programmes and international conferences/meetings attended by SUPARCO

3.2. A large number of SUPARCO scientists and engineers were sent to institutes of higher learning abroad during the past several years to pursue advanced studies leading to the M.S. or Ph.D. degree in various disciplines of space sciences and space technology. At present 44 scientists and engineers are studying abroad.

3.3. SUPARCO scientists/engineers attended more than 30 conferences/meetings during the period under review.

University collaboration

3.4. Under the continuing collaboration between SUPARCO and the University of Karachi, SUPARCO scientists provided teaching support in the Space Physics course as part of the Master of Science (M.Sc. Physics) programme of the university, as in previous years.

3.5. In a similar collaboration, senior SUPARCO scientists delivered lectures on space science to students in the Bachelor of Science programme of the Department of Space Science, University of the Punjab, Lahore.

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3.6. SUPARCO scientists delivered lectures on remote sensing to M.Sc. students of the departments of Geology and Environmental Studies at the University of Peshawar. A senior scientist has also been nominated as a member of the Board of Studies in Geology (for remote sensing) of the University of Peshawar.

3.7. A group of six M.Sc. students from the Department of Physics, University of Karachi, successfully completed their thesis entitled "A comparative study of the variations of foF2 and M3000F2 at Islamabad as a function of sunspot number during solar maximum (1979-1981) and solar minimum (1985-1987) years". Another group of five students in the Bachelor of Engineering (B.E.) programme from the Department of Electronic Engineering, Mehran University of Engineering and Technology, Jamshoro, successfully completed their project entitled "Project report on ionosphere at Karachi Ionospheric Station (SUPARCO)". Both the M.Sc. thesis and B.E. project were completed using SUPARCO's ionospheric data under the guidance of the Director of the Ionospheric Research Division.

Aerospace Institute

3.8. SUPARCO is in the process of setting up an Aerospace Institute at Islamabad to provide for its growing needs for qualified and trained manpower in various specialized fields of space science and technology. In addition to conducting regular postgraduate courses, the Institute will also conduct short preparatory courses for scientists and engineers preparing to go abroad for advanced training studies. The training facilities at the Institute could also be used for meeting the requirements of trained manpower of other national organizations involved in research and development as well as those of the Islamic Ummah and other developing countries.

3.9. The Institute will conduct postgraduate courses in various disciplines of space science and technology, namely, aerodynamics, mechanics, heat transfer, propulsion, quality assurance and testing, tracking, telemetry, telecommand and digital communications, computers, simulators, fibre optics, lasers, control systems, remote sensing and sensor technology, satellite communications, launch vehicles, satellite structure, etc. The training programmes will lead to award of the Master of Philosophy (M.Phil.) degree in space science and the Master's degree in space technology upon the successful completion of a two-year course. The Institute will have its own directing staff, making up the core of the teaching staff. They would be assisted by part-time instructors, who would be scientists and engineers working on relevant projects in SUPARCO.

4. International collaboration

Foreign space agencies

4.1. Various foreign national and international space agencies have been co-operating with SUPARCO in the exchange of technical information, provision of data, consultancy services, training activities and collaborative studies in areas of mutual interest. These agencies include the National Aeronautics and Space Administration (NASA) and National Oceanic and Atmospheric Administration (NOAA) of

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the United States, Centre National d'Etudes Spatiales (CNES) of France, the Swedish Space Corporation (SSC), British National Committee on Space Research (BNCSR), Deutsche Forschungs-anstalt fur Luft-und Raumfahrt (DLR) of Germany,* the Indian Space Research Organization (ISRO)/National Remote Sensing Agency (NRSA), the European Space Agency (ESA) and the Chinese Academy of Science/Chinese Academy of Space Technology (CAST).

4.2. A memorandum of understanding between SUPARCO and SPOT IMAGE of France was signed in June 1988 at Karachi for the acquisition of SPOT HRV data and distribution of SPOT HRV data and derivative works and products by the SUPARCO Satellite Ground Station (SGS), Islamabad.

International/regional organizations

4.3. As a member of the United Nations Committee on the Peaceful Uses of Outer Space, Pakistan has regularly participated in the annual sessions of the Committee and its sub-committees. SUPARCO scientists represent Pakistan on the Committee as well as on the Scientific and Technical Sub-Committee. Pakistan has been making a regular voluntary contribution for the past several years in support of the United Nations Space Applications Programme. During the current year Pakistan made a cash contribution of $US 12,000 for 1990. The United Nations Outer Space Affairs Division, IOMAC and the Government of Pakistan/SUPARCO also jointly organized a workshop on oceanographic/marine space information systems for the Indian Ocean region at Karachi from 2 to 6 July 1989.

4.4. SUPARCO is an adhering member of the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU). In this capacity, SUPARCO participates in the COSPAR biennial plenary meetings and associated symposia, workshops, meetings, etc. SUPARCO scientists represent Pakistan on the following COSPAR Sub-Commissions: A.1 - Meteorology and Climatology of the Lower Atmosphere, including fundamental dynamic processes in the oceans; and B.2 - International Co-ordination of Space Techniques for Geodesy and Geodynamics.

4.5. Pakistan is a State member of ESCAP. As Pakistan's national space agency, SUPARCO has been actively participating in ESCAP's UNDP-funded Regional Remote Sensing Programme (RRSP) for the development of remote-sensing capabilities in the ESCAP region. SUPARCO scientists/engineers have been attending seminars, workshops and training courses organized by ESCAP under the aegis of RRSP in different countries of the region on various themes related to remote-sensing applications. Senior SUPARCO scientists have also been attending the meetings of the Directors of the remote-sensing centres/programmes of the countries of the ESCAP region and, as a member, the associated Meetings of the Intergovernmental Consultative Committee (ICC) of RRSP. Senior SUPARCO scientists also function as the national contact

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* Through accession of the German Democratic Republic to the Federal Republic of Germany with effect from 3 October 1990, the two German States have united to form one sovereign State. As from the date of unification, the Federal Republic of Germany acts in the United Nations under the designation "Germany".

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point in Pakistan for education and training and for the resource information system (RIS) of RRSP. SUPARCO, ESCAP/RRSP and UNDP also jointly organized a symposium on remote-sensing applications for resource development and environmental management at Karachi from 23 to 26 July 1989.

4.6. FAO has been extending support to SUPARCO by sponsoring the attendance of SUPARCO scientists/engineers at training courses on remote-sensing applications organized/co-organized by FAO.

4.7. The Committee on Science and Technology of the Organization of the Islamic Conference (OIC) has decided to establish information networks linking the Islamic countries in selected fields of science and technology. The Inter-Islamic Network for Space Science and Technology will be co-ordinated by Pakistan.

4.8. SUPARCO and the International Centre for Theoretical Physics (ICTP) at Trieste, Italy, signed a Federation Agreement in September 1988. Under the Agreement, SUPARCO would nominate a minimum of three scientists to visit ICTP for specialized studies in areas of interest to SUPARCO. The timing and duration of the training would be mutually determined by SUPARCO and ICTP.

4.9. As a member of the South Asian Association for Regional Co-operation (SAARC), Pakistan participates in the meetings of the SAARC Scientific and Technical Committee to promote co-operation among the members of the Association in various fields of science and technology, including remote sensing.

4.10. Pakistan is also represented in the World Meteorological Organization (WMO), the International Telecommunication Union (ITU), INTELSAT, INMARSAT, the International Astronautical Federation (IAF), the International Union of Radio Science (URSI), the World Conservation Union (formerly the International Union for Conservation of Nature and Natural Resources, or IUCN) and the Asian Association of Remote Sensing (AARS).

5. Activities considered suitable for greater international co-operation

5.1. The space activities which should be the subject of greater international co-operation, keeping in view the needs of the developing countries, should include:

(a)* Technical co-operation for transfer of technology, mutual exchange of experts and provision of consultancy services and training opportunities in the following areas:

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* The text of subparagraphs (a)-(e) originally appeared in document A/AC.105/401/Add.1, pp. 1 and 2.

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(i) Remote-sensing applications to Earth resources survey and environmental studies (training of personnel in various disciplines of remote-sensing technology and applications, sensor development, aerial remote-sensing, photo processing, development of image processing software, etc.);

(ii) Operation, maintenance and licensing of remote-sensing satellite ground stations and co-ordination in remote-sensing space segment;

(iii) Development of satellites and their launching, interface with terrestrial communication infrastructure, software and hardware aspects of the Direct Broadcast Satellite (DBS, free or subsidized availability of television/telephone transponders on satellites for promotion of education, health care and communications, particularly in rural areas of developing countries;

(iv) Space meteorology (development of data-processing software, meteorological sensor development, establishment of high-resolution picture transmission (HRPT) stations for data reception and processing, fabrication of DCPs, training of personnel in the areas relating to space meteorology;

(b) Provision of assistance to the developing countries in the form of consultants for rendering advice in the preparation of project proposals, installation, commissioning and maintenance of the equipment and making available the satellite transponders for communication and television broadcast services on a long-term basis;

(c) Establishment of a centralized data bank accessible through computer terminals and provision of improved information exchange service in the form of physical exchange of technical documentation;

(d) Holding of joint meetings of space scientists and technologists of the developing and developed countries in order to facilitate the process of implementation of space science and space technology related projects in developing countries;

(e) Encouraging the extensive co-operation among countries within a region through sharing their resources of manpower, technical know-how, hardware and software for the projects falling in the application areas mentioned in subparagraph (a) above. The Regional Remote Sensing Programme (RRSP), a project of the United Nations Development Programme (UNDP) and the Economic and Social Commission for Asia and the Pacific (ESCAP), is an excellent example of this;

(f)* Sharing of experience by the technologically developed countries with the developing countries in various fields relating to space technology and space sciences (examples: design and development of low-cost satellite systems for communication; remote-sensing and meteorological applications; development of satellite launching capability; design of hardware for scientific experiments on board a spacecraft, etc.);

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* The information contained in subparagraphs (f)-(j) was provided in response to the Secretary-General's communication of 30 June 1989.

(g) Provision of launch services, at reduced rates, by the developed countries for the satellites developed by the developing countries;

(h) Placement of scientists/engineers of the developing countries in the establishments located in the developed countries engaged in the space technology related activities, in order for them to gain hands-on experience;

(i) Accommodating scientific experiments designed by the developing countries involved in space research activities, in the spacecraft operated by the developing countries;

(j) Wide dissemination of scientific/technical information relating to the spin-off benefits emanating from the activities of the space-faring nations in outer space and assisting developing countries in their useful applications.

5.2. Pakistan has already announced training opportunities for the scientists/engineers of the developing countries in the following fields:*

(i) Ionospheric studies;

(ii) Remote-sensing applications to Earth resources survey;

(iii) Design and development of ground terminals for reception of signals from direct television broadcasting satellites.

6. Information on the implementation of the priority recommendations of UNISPACE 82 (as identified in paragraph 9 of General Assembly resolution 44/46 of 8 December 1989)

Opportunity to use the techniques resulting from medical studies in space

6.1. At present, SUPARCO, the national space agency, is not engaged in medical studies carried out in outer space. However, it maintains a deep interest in developments in this field and would like the developed countries making progress in this area to share their experiences extensively with the developing countries.

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* See A/AC.105/366/Add.1 and A/AC.105/432.

Strengthening/expansion of data banks at national and regional levels and establishment of an international space information service

6.2. In consideration of the rapid developments in space science and technology, as well as in the areas of computers and communications, and the need for timely access to the voluminous, updated information for its effective utilization, SUPARCO installed an information retrieval system at Karachi in 1987.

6.3. A PC-based system having on-line access to data bases of the Information Retrieval Service (IRS) of ESA is capable of retrieving information on-screen as well as in printed form for delivery to users located away from the facility. A number of data bases on space science and technology, including SATELDATA, SPACESOFT, INSPEC, ELECOMPS, SPACE components, NASA, COMIC, etc., were accessed and information was provided to various technical user divisions of SUPARCO. Data bases on publications/documentation available in SUPARCO are also being developed for easy access to all users in various establishments of SUPARCO. The system will also be used for the Inter-Islamic Network on Space Sciences and Technology being established at SUPARCO to enable quick exchange of information between the Islamic Ummah countries.

6.4. In accordance with General Assembly resolution 42/68 of 2 December 1987, the Outer Space Affairs Division of the United Nations had carried out a survey of existing space information services at the national and international levels, with a view to establishing an international information system. That survey resulted in the publication of a directory on information systems on space science and technology (A/AC.105/397/Rev.1 and Add.1). The document also contains relevant information about Pakistan.

Creation of adequate training centres at the regional level, linked, whenever possible, to institutions implementing space programmes

6.5. The United Nations should take the necessary steps towards supporting the creation of the adequate training centres at the regional level. Necessary funding for the development of such centres, as well as for enhancing the overall activities concerning the peaceful uses of outer space under the auspices of the United Nations, may be made available through the following possibilities:*

- Increase in United Nations financial allocations;
- Intensive participation of United Nations agencies such as the World Bank, the International Monetary Fund, the International Finance Corporation, UNESCO and UNDP, through contribution of sufficient funds on a regular basis to the Space Applications Programme;
- Regular contributions in cash or in kind by all Member States;

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* See A/AC.105/401/Add.1.

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- Financial support of the multinational companies engaged in space programmes/activities;

- Creation of an endowment trust.

Organization of a fellowship programme

6.6. Although many opportunities are made available through the United Nations Outer Space Affairs Division to the developing countries for the placement of their scientists/engineers in the educational and research institute of the developing countries for their training in space science and technology and its applications, there is a need for the United Nations to take the necessary steps to provide opportunities to the selected graduates/postgraduates from developing countries for their in-depth, long-term exposure to space technology in the specific areas mentioned in paragraph 5.1 above.

POLAND

[Original: English]

The Committee on Space Research of the Polish Academy of Sciences is the organization which co-ordinates space activity in Poland. The institution responsible for concentrating and promoting scientific investigation in all domains of space exploration as well as the application of space techniques for practical needs is the Space Research Centre of the Polish Academy of Sciences. A number of other institutes and laboratories take part in the Polish space programme, which is based on the Intercosmos international co-operation programme and on several bilateral agreements with scientific institutions in Austria, Denmark, Finland, France, Germany, Ireland, the Netherlands, Norway, Sweden, Tunisia, the United Kingdom of Great Britain and Northern Ireland and the United States of America.

The financing of the activities is provided by the Central Programme of Fundamental Research (CPBP) on the advice of the Committee on Space Research of the Polish Academy of Sciences and other interested specialists.

I. SATELLITE GEODESY

1. Investigation of the rotation of the Earth

In the recent investigations concerning the effect of atmospheric excitation on polar motion the atmospheric angular momentum function was computed. It was shown that this problem could be solved by taking into consideration periods of the order of one day and using a full form of the polar motion equation. Attention was focused on the Kalman filtering method combined with the autoregressive modelling of the excitation process. The general filter equations were derived using complex rotation and the observability conditions were discussed.

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The analysis of the short periodic perturbation in the rotation parameters of the Earth was carried out during the second half of 1987 and the first half of 1988. The period was of especial interest owing to the fact that in the beginning of 1988 large short periodic variations occurred in both the polar motion and the length of the day. The aim of the investigations was to obtain the characteristic of the perturbations - their amplitudes, periods and phases.

2. GPS positioning

The first Global Positioning System (GPS) observation campaign in Eastern Europe was organized in Poland by the Space Research Centre of the Polish Academy of Sciences, the Geodetic Institute of the Stuttgart University, Germany, and the Department of Geodesy of the Royal Institute of Technology, Sweden. The main goal of the campaign was to establish the geodetic connection between two geodynamic observatories: the Jósefosław Astronomical-Geodetic Observatory and that of the Warsaw Technical University.

3. Doppler positioning

Permanent Doppler observations were carried out at the Astronomical Observatory of the Space Research Centre at Borowiec, Borowa Góra, Lomkówko. Two Doppler observations campaigns were organized, in Poland and in the Union of Soviet Socialist Republics, respectively. The processing of Doppler data from the ICDOC campaign was carried out and the final positions of 17 Intercosmos stations were computed.

4. Laser observations

Hardware and software were developed for the satellite ranging system of the II generation, installed in 1986 at Borowiec. The precision of laser observations performed at Borowiec in 1989 is on the level of 20 cm.

5. Mars gravity field by satellite-to-satellite technics

The possibility of the application of a satellite-to-satellite tracking method for the investigation of the gravity field of Mars was examined. The results indicate that the predicted precision of the modified system renders possible the 60-60 resolution of the Mars gravity field model precise range and range-rate equipment (PRARE). The influence of the atmosphere of Mars on satellite motion (for attitudes of 100-500 km above the surface of the planet) was investigated.

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II. SPACE PHYSICS

The main activity in the field of space physics in Poland during 1988-1989 was closely related to the country's direct participation in the current space missions, the design and construction of scientific instruments for future projects, the elaboration and interpretation of the data received from earlier experiments, as well as to the wide spectrum of various theoretical studies.

The most important experimental ventures in the past two years in which Polish instruments have been installed on board the spacecraft were the launches of the two interplanetary probes Phobos-1 and Phobos-2 and the Intercosmos-24 satellite.

The Phobos-1 and Phobos-2 space probes, launched towards Mars and its satellite Phobos on 7 and 12 July 1988 respectively, were equipped with the low-frequency plasma wave APV-F analyser which included a Polish Bas wave spectrum unit. The analyser made possible the measurement of the fluctuations of the electric and magnetic field components with high resolution and therefore afforded the opportunity to study plasma phenomena in the environment of the Earth, Mars, Phobos and in the interplanetary space within the frequency range 0.1-40 kHz.

Several other instruments constructed in the Space Research Centre of the Polish Academy of Sciences were placed on board the Intercosmos-24 satellite, launched on 28 September 1989 for the purpose of performing the ionospheric studies in the framework of the "Active" project. The function of the set of instruments - consisting of two radiospectrometers (0.1-10 Mb), an impedance meter for the antenna (0.1-10 MHz), a low-frequency spectrum analyser (20 Hz-20 kHz) and the analogue unit of the telemetry - was to perform the complex diagnostics of the natural and artificially generated (by injection of a whistler wave from the spacecraft) plasma waves in the Earth's ionosphere. The data received during the initial phase of the mission are now being compiled and analysed.

In addition to the instruments included on recent launches, several other detectors for various experiments are now in the advanced phase of preparation for future space projects which will be carried out in the framework of the Intercosmos programme in the coming years. Among these, the flight versions of the set of experimental instruments for the "Interball" space project are now in the final phase of preparation. This includes the detector for the measurement of the polarization characteristics of the terrestrial kilometric radiation, the plasma-wave dynamic spectra analyser and the FR-15-I X-ray photometer units for the X-ray observation of the Sun.

Apart from the instruments mentioned above, several other devices containing the X-ray spectrometer-dopplerometer Koronas project wave analyser for ionospheric and magnetospheric diagnostics (for the Apex, Koronas, Mars-94 projects) as well as the electronics units for the energetic neutral particles detector for use in the Relict-2 interplanetary space project are now being developed at the Space Research Centre of the Polish Academy of Sciences for future space missions, which will be carried out in the framework of the Intercosmos programme. The recent compilation and analysis of the experimental data has been mainly focused on the results of measurements performed by the low-frequency plasma wave analysers placed on board

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the Vega and Phobos spacecrafts launched towards Halley's comet and Mars, respectively. The well-known difficulties with the Phobos mission precluded the accomplishment of the entire comprehensive programme of measurements of low-frequency plasma waves in the environments of Earth and Mars and in the interplanetary medium. However, partial experiments performed during the cruise phase of the mission from the Earth to Mars yielded some valuable data on the existence of enhanced wave activity which correlated with intersection of the interplanetary shocks and sectors of the interplanetary magnetic field.

Besides the activities related to its direct participation in future space experiments and the compilation and analysis of the experimental data, numerous theoretical research projects were developed in Poland during the period 1988-1989.

The activity of Polish groups in heliospheric physics led to the organization of the first Committee on Space Research (COSPAR) colloquium on "Physics of the outer heliosphere", held at Warsaw from 19 to 22 September 1989. The meeting grouped together over 100 participants from many countries and provided them with the opportunity to present the results of current studies and to discuss specific problems related to the interaction between the local interstellar medium and heliospheric plasma, penetration of the neutral interstellar gas and galactic cosmic rays into the heliosphere and the characteristics of the solar wind and the behaviour of the magnetic field in the distant heliosphere as observed by the Pioneers and Voyagers spacecraft.

III. REMOTE SENSING

Research on the development of remote-sensing methods and techniques advanced significantly during the reporting period. This work concentrated on the use of high-resolution satellite data (Landsat TM SPOT images, Cosmos photographs), which are the main remote-sensing inputs to the data bases constituted within the geographical information systems concerning the environment, and known as SINUS (which was developed in Poland) and ARC/INFO. Work continued on the research related to the construction of new instrumentation for the acquisition and processing of remotely sensed information.

The most important research work carried out and new products developed in the period under discussion were as follows:

(1) Hauling carrier of hydro-acoustic digital instrument which surveys the sea floor and records echograms with aided information (Institute of Ships, Szczecin Technical University, Department of Data Processing and Marine Automation);

(2) ASS-1 Acoustico-optical solar spectrometer (laboratory model) for the analysis of the atmosphere through measurements of the spectral characteristics of the Sun (Space Research Centre of the Polish Academy of Sciences);

(3) Microprocessor-based system for the hydro-acoustic mapping of the sea floor, used for controlling and recording high-speed pulses (Institute of the Ships, Szczecin Technical University, Department of Data Processing and Marine Automation);

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(4) GRAFAP image processing system, designed for interactive analysis of images (Institute of Ships, Szczecin Technical University, Department of Data Processing and Marine Automation). The system has been prepared for IBM PC/AT 386 computers with a 80286 co-processor and a high-resolution colour monitor (720 x 640 pixel);

(5) Information system based on remotely sensed data (Institute of Geodesy and Cartography (IGC). The system comprises software for feeding data bases with spatial data; it is used for digitizing information from interpretation overlays as well as for creating and verifying data bases. The software has been prepared for IBM PC compatible computers, Summa Sketch/Laipen digitizers and HP Draft Master I/Rolland DXY 880 plotters;

(6) Method for correcting spatial data stored in a vector data-base (IGC). The software prepared enables changes in spatial data stored in vector data bases, by removing bad lines and replacing them with new ones, using an arbitrary scale of data presentation on the graphic monitor. The use of a mouse or a digitizer makes the communication of the operator with the data base much more efficient. The method has applications for coding overlays involving interpretation of satellite data as well as for other cartographic materials feeding the data base of the SINUS system;

(7) Interactive area coding (IGC). This method is based upon a process of picking up particular areas on the monitor screen and assigning them thematic codes, while simultaneously filling with the proper cartographic pattern. The method has applications for the coding interpretation of satellite data as well as for other cartographic materials feeding the data base of the SINUS system;

(8) Interactive digitalization of line drawings (IGC). The method is based upon the presentation of the digitized geometrical objects simultaneously with the process of digitization. It allows for the choice of an arbitrary scale of presentation and for direct corrections of the collected numerical data. The method is used for digitizing data derived from satellite images which feed the data base of the SINUS system;

(9) Mapping of the transparency of lake water on the basis of multi-temporal Landsat MSS and TM satellite images (IGC). This method is based upon the appropriate radiometric calibration of Landsat MSS and TM images and such processing which enables the assessment and mapping of water transparency on the basis of multitemporal data, using a uniform mathematical model for all dates and types (MSS and TM), which describes the relationship between processed satellite data and the transparency of water. Accuracy of determination of water transparency: + 0,5 m. The following are the classes of transparency determined by the use of this method (according to the classification system of the Institute of Environment Protection): I - 4 m; II - 2-4 m; III - 2-1 m; IV - 1 m;

(10) Two-stage nadir rectification of the oblique photogrammetric photographs (IGC). This method has applications in the rectification of Soviet Cosmos space photographs, which are used for updating topographic maps (Patent No. 26 09 84; decision KP of 5 October 1989, of the Institute of Geodesy and Cartography);

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(11) Analysis of changes in agriculture (1988-1989) in the area of the Narew test site and analysis of changes in water conditions (1967-1987) (Institute of Geography, Warsaw University). Various types of data collected during the Telegeo-87 Intercosmos experiment (aerial photographs, satellite images, ground-truth data) were used in this work.

IV. SPACE METEOROLOGY

The research work of the Institute of Meteorology and Water Management as connected with the processing and application of the high-resolution picture transmission (HRPT) data of the National Oceanic and Atmospheric Administration (NOAA) of the United States for environmental studies.

The software allows the mathematical processing for the determination of: Baltic Sea surface temperature; soil surface temperature of the river basins; vegetation index; urban heat islands; environmental changes in the mining areas; radiation budget; and three-dimensional distribution of the atmospheric temperature, moisture and ozone.

The ATMOSATLAND system is also provided for the processing of SPOT, LANDSAT and KOSMOS digital images.

The resolution of advanced very-high-resolution radiometer (AVHRR) images obtained from NOAA satellites is much lower than that obtained from environmental LANDSAT, SPOT and KOSMOS satellites. Taking into consideration the economic aspect and access to transmitted data in real time, the Institute of Meteorology and Water Management in Poland prefers RPT/NOAA data not only for meteorology but also for water management, agriculture, land surface, oceanographic and environmental studies.

The low-cost ATMOSATLAND system which has been created, allows for the processing of full HRPT transmission data obtained from NOAA series polar orbiting satellites. The ATMOSATLAND software was also modified for IBM-PC-386 with a video graphics array (VGA) monitor which increases the speed of the processing time and the vision quality.

The following topics are currently under investigation:

- Determination of chlorophyl and sediment content in the Baltic Sea;
- Estimation of the soil temperature and moisture on the area of river basins for purposes of operational hydrology;
- Observation of seasonal changes of the vegetation index for agriculture forecast modelling;
- Determination of the photosynthetically active radiation from AVHRR data for agricultural needs;

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- Multispectral analysis of SPOT, LANDSAT, KOSMOS and NOAA images for pattern recognition;

- Determination of the ozone and temperature stratospheric fields.

Future work will be mainly concentrated on application of AVHRR and TOVS data for agricultural purposes.

V. SPACE BIOLOGY AND MEDICINE

The research in the field of space biology and medicine concerns space cytophysiology and physiology, radio-biology and psychology. Most of the data are from the animal and human studies performed in conditions of real flight, but comparative studies in simulated conditions on Earth were also performed.

The effects of weightlessness were examined in adrenal and myocardial cells of animals after flight on biosatellites by ultrastructural methods. Additionally, the remote consequences were indicated by the examination of two components of ovarian follicles manifesting disturbances of estrogen and androgen production.

A hypokinesia model in animals as a laboratory counterpart to weightlessness was used and the activity of the kidney as a function of the level of nephron ultrastructural exponents of tubular transport was studied.

Human studies concentrated on the effect of helium respiratory mixtures on possible candidates for long-duration flight atmospheres. In addition, objective computer-aided methods and instrumentation for on-board evaluation and control, the physical fitness of the space crew were developed and tested in real-flight conditions. The response of the cardiovascular system to low body negative pressure stimuli was also studied in order to evaluate individual compensatory capabilities.

VI. SPACE COMMUNICATIONS

At the Institute of Telecommunications, studies were carried out on the problem of the choice of the optimum transmission system of television D/K-SECAM signals for a satellite broadcasting service.

The work of such international organizations as the International Radio Consultative Committee (CCIR), the European Broadcasting Union (EBU), the International Radio and Television Organization (OIRT), etc., indicates that the transmission of colour signal components gives better picture quality than the transmission of a composite colour signal (NTSC, SECAM or PAL). The advantages of components transmission include: independence from the colour television system (NTSC, SECAM or PAL); elimination of cross-colour and cross-luminance; and reduced intermodulation between chrominance signals and harmonic signals from line synchronization and sound signals.

The agreement between the European Telecommunications Satellite Organization (EUTELSAT) and the Polish Post, Telegraph and Telephone was signed on 1 March 1990. Poland has thus become a member of EUTELSAT. In the near future the first transmitting station of that system will be established in Poland.

SWEDEN

[Original: English]

1. National organization of space activities

The Swedish National Space Board, under the Ministry of Industry, is the central governmental agency responsible for the Swedish national and international space and remote-sensing programme. For the research programme the Board receives funds from the Ministry of Education and Cultural Affairs.

The Parliament, the scientific community, the space industry, the Telecommunications Administration and the National Board for Technical Development are represented on the Board. The responsibilities of the Board include:

(a) Initiating research, development and other activities connected with the Swedish space and remote-sensing programme;

(b) Co-ordination of Swedish activities within the fields of space technology and research as well as remote sensing;

(c) Distribution of government appropriations for Swedish space activities;

(d) Authorization and supervision of space activities in accordance with space law;

(e) Maintaining contacts with international organizations and institutions operating within the field of space activities and remote sensing.

The Board has three advisory committees: for industrial policy, science (including microgravity) and remote sensing respectively. The technical implementation of the space and remote-sensing programmes are mainly contracted by the Board on an annual basis to the state owned Swedish Space Corporation (SSC).

The principal responsibilities of the Swedish Space Corporation are: (a) the technical implementation of the Swedish space and remote-sensing programmes; (b) to conceive, specify and procure satellites for applications and space science research; (c) to operate the ESRANGE sounding rocket range and satellite control/reception facilities; (d) to perform system management and engineering for complex high-technology projects; (e) to receive image data from remote-sensing satellites at Esrange; to process and analyse such images into map products for customers all over the world; and (f) to develop and supply operational remote-sensing systems for maritime surveillance and environmental control.

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The Swedish Space Corporation has two establishments: at Esrange, Kiruna, and in Stockholm (the headquarters). A subsidiary of the Swedish Space Corporation, SSC Satellitbild, has been established at Kiruna.

The Swedish public space expenditures for the fiscal years 1989/90, 1990/91 and 1991/92 are given below in millions of kronor (SKr 1 = approx. $US 6):

	Fiscal year		
	1989/90 (actual)	1990/91 (budget)	1991/92 (proposed budget)
International programmes	323	459	477
National programmes	95	102	114
	418	561	591

2. Manned spaceflights

Possible participation is anticipated in the manned space activities within the Columbus and Hermes programmes of the European Space Agency (ESA).

3. Space applications programmes

3.1. Remote sensing of Earth resources and environment

The past years have been characterized by development and consolidation of remote-sensing activities in Sweden. New, advanced equipment has been made available through development within the country, through purchase or through international co-operation. Several major co-operative field experiments have been carried out, the objective of which is to assess the potential of the technology for various applications, but above all to acquaint potential users with the available technology at an early stage.

The following developments can be noted in particular. The operational remote-sensing system for airborne maritime surveillance which has been developed by the Swedish Space Corporation for the Swedish Coast Guard has enjoyed further commercial success. The system, which uses a sidelooking airborne radar (SLAR), an IR/UV-scanner and a passive microwave radiometer, has been sold to the Netherlands,

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the United Kingdom of Great Britain and Northern Ireland, Germany* (two systems), Portugal (three systems), India and China. In addition, sub-systems have been sold to several countries.

The Esrange facility, which has been receiving and processing Landsat data on behalf of ESA since 1978, has been upgraded and also receives SPOT data on behalf of Centre National d'Etudes Spatiales (CNES), France. Data are also received from the MOS polar satellites (Japan) and on an experimental basis from Resurs and Okean (USSR), and an agreement has been concluded with ESA to receive and process ERS-1 data once that satellite is launched. A separate ESA facility has been established for that purpose at Salmijärvi (near Esrange).

SSC Satellitbild at Kiruna is processing and distributing SPOT data in co-operation with the French company SPOT Image. Its processing facility is one of the two principal stations in the SPOT network. SSC Satellitbild specializes in providing geometrically precision-corrected Landsat and SPOT data for the world market.

Sweden co-operates with France on the SPOT satellite system.

Three Swedish companies have developed commercially available systems for digital analysis of remote-sensing image data. Sweden vigorously promotes the practical application of remote-sensing technology. Particular emphasis is placed on the integration of remote-sensing data with other types of geographical data.

Sweden participates in the ESA programme for receiving, pre-processing, archiving and distribution of images from remote-sensing satellites (Earthnet). The Swedish ground station at Esrange, Kiruna, forms part of the system and is collecting Landsat data on a routine basis. The Swedish Space Corporation is the National Point of Contact.

Sweden also participates in the remote-sensing programmes of ESA such as the programme for the development of remote-sensing satellites (ERS-1 and ERS-2) and the Earth observation preparatory programme.

3.2. Meteorology

Cloud-cover photographs and other meteorological data from ESA, United States and Soviet weather satellites are received regularly by the high-resolution picture transmission (HRPT) and automatic picture transmission (APT) stations of the Swedish Weather Services and were used in weather forecasting.

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* Through accession of the German Democratic Republic to the Federal Republic of Germany with effect from 3 October 1990, the two German States have united to form one sovereign State. As from the date of unification, the Federal Republic of Germany acts in the United Nations under the designation "Germany".

A project involving the establishment of short-term weather forecasting and regional weather service based on advanced space and remote-sensing techniques, including weather radar, SODAR, microwave radiometry and weather satellites, has entered into an operational phase.

Development work is proceeding on the operational use of advanced digital image analysis of polar weather satellite data. A microwave radiometer for sounding of temperature and humidity of the atmosphere has been developed for operational use.

3.3. Communications

Sweden participates in the communications programmes of ESA such as the European Communications Satellite (ECS) programme, the advanced systems and technology (ASTP) programme, the payload and spacecraft development and experiments (PSDE) programme and the data relay satellite (DRS) programme.

On a national level, the Swedish Space Corporation operates the Tele-X telecommunications satellite system. Tele-X provides the following services: (a) high-speed digital data and video communications, 64 kbit/s - 2 Mbit/s, using small Earth stations; and (b) direct TV-broadcasting to small (30-cm diameter) home receivers. The satellite was launched on 2 April 1989 on an Ariane-2 launcher from the Guyana Space Centre in Kourou.

3.4. Navigation

Satellite navigation equipment is in routine use on Swedish merchant vessels using Transit-type satellites.

4. National Scientific Space Programmes

The scientific activities of the Swedish research groups are mainly the following:

(a) Magnetospheric and ionospheric physics, in particular measurements of charged particles and electric and magnetic fields using satellite experiments, sounding rockets and balloons. Groups: Swedish Institute of Space Physics, Kiruna; Swedish Institute of Space Physics, Uppsala; Department of Plasma Physics, Royal Institute of Technology, Stockholm;

(b) Study of the upper atmosphere (80-150 km), in particular, atmospheric processes and composition at high latitudes using sounding rockets. Group: Institute of Meteorology, Stockholm University;

(c) Astrophysics, in particular, studies of solar and stellar UV radiation and IR studies using satellites, sounding rockets and balloons in international co-operative ventures. Groups: Lund Observatory, University of Lund; Stockholm

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Observatory, University of Stockholm; Uppsala Astronomical Observatory, University of Uppsala; Onsala Space Observatory, Chalmers University of Technology, Gothenburg.

(d) Materials sciences, in particular, solidification processes of metals, diffusion processes in liquid metals and crystal growth in microgravity using sounding rockets. Group: Department of Metals Casting, the Royal Institute of Technology, Stockholm;

(e) Life sciences, in particular, studies of human physiological processes in microgravity. Group: Department of Baromedicine, Karolinska Institutet, Stockholm;

(f) Biophysics, in particular, electrophoretic and protein crystal growth studies in microgravity. Group: Department of Physical and Inorganic Chemistry, Chalmers University of Technology, Gothenburg;

(g) Remote sensing, in particular, microwave radiometry, spectral signatures and image analysis using satellite images and registrations from airborne or land-based sensors. Groups: Department of Radio and Space Science, Chalmers University of Technology, Gothenburg; Remote Sensing Laboratory, Department of Physical Geography, University of Stockholm; Remote Sensing Laboratory, Department of Physical Geography, University of Lund; Department of Physics, Lund Institute of Technology; Remote Sensing Laboratory, Swedish University of Agricultural Sciences. (Note: Several groups are engaged in research concerning remote sensing; only the largest and most active groups are listed above. Details on the activities are given in "Space research in Sweden", published biannually for the COSPAR meetings.)

4.1. Satellites

Viking - Sweden's first satellite

The scientific satellite Viking was the largest individual project within the national space research programme during 1986 and 1987. Viking was launched by the Ariane V-16 rocket from Kourou on 22 February 1986. On 12 May 1987, after 444 days Viking stopped functioning due to gradually decreasing power generation. The original lifetime of eight months was thus nearly doubled.

The scientific objective of the Viking satellite was to study the ionospheric and magnetospheric phenomena at high geomagnetic latitudes in the altitude region up to about two Earth radii. Simultaneous measurements were made of electric and magnetic fields, particle distribution, plasma composition and waves as well as imaging in the ultraviolet of the aurora beneath. The instruments were supplied by the three Swedish magnetospheric groups mentioned above as well as by scientific teams in Denmark, Norway, France, the Federal Republic of Germany, Canada and the United States. All systems and instruments on board functioned very well.

Viking was operated from Esrange, Kiruna, in the northern part of Sweden, where the telemetry data from the satellite were received and processed on a real-time basis. The scientific data were displayed almost immediately and different experimental modes could be commanded and changed on a nearly real-time

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basis. Specific "campaigns" were conducted at Esrange focusing on specially selected scientific topics such as magnetic storms, ion beams, double layers, parallel electric fields, acceleration regions, polar cap arcs and kilometric radiation. Ground-based observations as well as measurements from balloons and rockets were co-ordinated with the Viking operation.

The scientific results of the Viking mission have been presented to the international community in symposia and conferences.

Freja - Sweden's next scientific satellite

Freja is a Swedish scientific satellite under development within the national space research programme designed to carry instruments for research into the aurora and other magnetospheric/ionospheric phenomena. The satellite, designed at low cost, is planned to be launched in 1992. The project will be carried out in co-operation with Germany.

The satellite will weight 230 kg in the final orbit, which will range in altitude between 650 and 1,800 km. The inclination of the orbit is 63-68 degrees. The scientific mission of Freja shares many similarities with the Viking mission. The auroral zone is the "mission target" and the satellite will carry energetic particle detectors, magnetic and electric wave experiments, electric field sensors and a UV imager. The Freja design strives to provide substantially higher rate of data acquisition than that of the Viking.

A combined astronomy and aeronomy satellite mission known as MOSES (Molecules in Outer Space and in the Earth Stratosphere) is under study.

Other satellite projects

PROMICS are joint Swedish-USSR experiments on board the PROGNOZ-satellites. The Institute of Space Physics at Kiruna and the Swedish Space Corporation have designed experiments to measure mass and energy distribution for ions and electrons in the magnetosphere. The PROMICS-1 and PROMICS-2 experiments were launched 1978 and 1980 respectively. A third PROMICS experiment is planned for launch within the Interball-concept.

The Institute of Space Physics at Kiruna participated in two hot plasma experiments (ASPERA) on board the USSR space probes (Phobos I and II) to Mars launched in July 1988 from Baikunur. In spite of damage to the probes, the Swedish research group obtained valuable data from Phobos II during its lifetime. That research group will also be involved in the planned USSR project Mars-94.

The Institute of Physics at Kiruna has participated in the development of a particle experiment for the ESA satellite Ulysses.

Both the Kiruna and the Uppsala departments of the Institute of Space Physics and the Department of Plasma Physics at the Royal Institute of Technology at Stockholm are involved in the Cluster project in the Solar Terrestrial Science Programme (STSP), the first cornerstone in the ESA space science programme Horizon 2000.

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The Stockholm Observatory and the Astronomical Institutes at Lund and Uppsala are participating in several guest investigator programmes on the International Ultraviolet Explorer (IUE) satellite launched in January 1978 and still in operation.

The Stockholm Observatory also takes an active part in the ESA satellite project Infrared Space Observatory (ISO) in the construction of an IR-camera (ISOCAM). Sweden also participates in the ESA satellite projects GIOTTO, HST and HIPPARCOS.

4.2. Sounding rockets and balloons

Swedish sounding rocket and balloon launches have been carried out since 1964 from Esrange, most of them as international co-operative projects. The Swedish sounding rocket and balloon programme is concentrated on four main areas: magnetosphere and ionosphere physics; upper atmosphere physics and chemistry; astrophysical infrared studies; and material and fluid science in microgravity. The Swedish Space Corporation is responsible for the technical execution of the projects as well as the operation of Esrange.

The Swedish Materials Science Experiment Rockets (MASER) programme, which started in 1987, offers one launch per year for experiments within material physics, fluid- and bio-science.

For projects requiring an apogee of 800-1,000 km, an attitude control system, in addition to the S19 boost guidance system, is necessary to decrease impact dispersion. A development of this new spinning rocket attitude control system (SPINRAC) started in 1986 and will be used in a flight from Esrange in November 1990.

ESA has shown interest in microgravity experiments of long duration utilizing existing rocket hardware. The Swedish Space Corporation has prepared a comparative study on long-duration sounding rockets (LDSR) for ESA. The LDSR programme, known as MAXUS, will be carried out jointly by Germany and Sweden and is based on a required payload weight of 600 kg and 14-15 minutes of microgravity. LDSR will be equipped with a modified guidance system partly based on SPINRAC. Sweden will be responsible for the facilities at Esrange and the guidance systems. The first launch from Esrange will take place in April 1991.

4.3. Ground-based experiments

Sweden participates in the work of the scientific association of the European Incoherent Scatter Facility in the Auroral Zone Centre (EISCAT). The association has installed a multistatic incoherent scatter facility in the auroral zone, comprising a system of stations at Tromsø, Norway; Kiruna, Sweden; and Sodankylä, Finland.

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5. Esrange

Esrange is a Swedish space research range situated in northern Sweden, close to the town of Kiruna, at a latitude of about 68° North. The base is managed by the Swedish Space Corporation.

Space research activities are carried out at Esrange in co-operation with other nations using ground-based instrumentation, sounding rockets, balloons and satellites. Due to the geographical location of the range, studies of the aurora and other high-latitude phenomena are of particular interest. The land recovery possibilities offered by Esrange make it very suitable for all sounding rocket experiments requiring recovery, e.g., microgravity research.

Esrange has the capacity to launch most types of sounding rockets, including high-performance vehicles. The range also has considerable experience in releasing scientific balloons.

The Esrange sounding rocket and balloon activities are supported by ESA. Contributing members of ESA can use the range on a marginal cost basis. Non-members of ESA are also welcome to use the facilities.

Esrange is also used in various satellite projects. A number of ground segments for the support of national and international spacecraft programmes are currently in operation or under development. The majority of the polar orbiting satellites have paths which fall within the coverage zone of the Esrange satellite ground stations.

A facility for the reception, recording, archiving, processing and dissemination of remote-sensing satellite data was established at Esrange in 1978. The station was originally used for spacecrafts in the Landsat series and operated within the framework of the European Space Agency's Earthnet programme. The Station has been extended to accommodate the SPOT satellites. A separate ESA facility, the Salmijärvi satellite ground receiving station, has been established and is dedicated to the European Remote Sensing Satellite ERS-1 and other satellites to be developed in the future.

A tracking, telemetry and control (TTC) station is used to support polar satellites during the launch phase and when in service in their nominal orbits. The Esrange TTC station was initially established to support the Swedish Viking satellite and the French SPOT-1 satellite. The station includes a dedicated operations centre and a display and analysis facility for scientific data.

The ground control station for Tele-X has been constructed at Esrange.

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6. Space-related facilities and installations, including telemetry and acquisition

Sweden operates a receiving station for Landsat data at Kiruna. The station constitutes an important element of the Earthnet network of receiving stations, which is managed by the European Space Agency. The station has been extended to accommodate the SPOT satellite. Data are received also from the MOS satellites and on an experimental basis from the Resurs and Okean satellites.

The Kiruna Landsat station has been collecting Landsat data on a routine basis since the spring of 1978. The data have been recorded on high-density digital tapes. In 1979 the station became fully operational, with the addition of a film product and computer tape generating capability.

Several image analysis systems for image data correction and manipulation are operated by the Swedish Space Corporation at Stockholm.

A subsidiary of the Swedish Space Corporation, SSC Satellitbild, has been established at Kiruna. Its main task is to process, analyse and distribute images from the SPOT and Landsat satellites.

Telemetry and tracking facilities for sounding rockets and balloons have been installed at Esrange, Kiruna. This equipment includes facilities for pulse code modulation telemetry and a digital conversion line.

The Onsala Space Observatory, located on the west coast of Sweden, operates radiotelescopes, chiefly for radio-astronomical observations. The newest telescope has a radome-enclosed 20-m-diameter reflector with very high surface accuracy for work at millimetre wavelengths.

A joint Scandinavian Intelsat Earth station is located at Tanum on the west coast of Sweden. A joint Scandinavian Earth station for the European Communications Satellite (ECS) system is located near Stockholm. A number of HRPT and APT weather picture receiving stations are also in operation.

7. International co-operation

Within ESA, Sweden participates in the mandatory basic and scientific programme, in the Ariane launcher project and the Hermes space plane project for future space transportation systems; the Columbus programme; the telecommunications programmes in the European regional communication satellite project; the advanced systems and technology programme and the preparatory programme for future telecommunications satellites in remote sensing including ERS-1, ERS-2 and Earthnet; and the microgravity programme.

The Swedish contribution to ESA for fiscal year 1990/91 is approximately SKr 365 million.

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Bilateral scientific co-operation between Sweden and the United States of America is carried out under an agreement with the National Aeronautics and Space Administration (NASA). Similarly scientific co-operation is carried out with the Soviet Union under a memorandum of understanding with the Intercosmos Council of the Soviet Academy of Sciences. Bilateral co-operative work on space science and applications is carried out between Sweden and France under an agreement with CNES.

Sweden and the Federal Republic of Germany have concluded memorandums of understanding on various projects, e.g., scientific co-operation in the Freja project and in the field of hypersonic technologies/Sänger. Memorandums of understanding have also been concluded as the basis for co-operation with Austria, Canada, India and China. Other bilateral co-operative efforts are carried out on an *ad hoc* basis, and Sweden has had co-operative projects with Denmark, Finland, Italy, Japan, the Netherlands, Norway, Switzerland and the United Kingdom.

Sweden is a member of the International Telecommunications Satellite Organization (INTELSAT), the European Telecommunications Satellite Organization (EUTELSAT), the International Maritime Satellite Organization (INMARSAT) and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT).

8. Other activities

Sweden has broad experience in remote-sensing and geographical information systems at governmental agencies, universities and companies. This experience and know-how could be made available to developing countries where there is need for mapping and other forms of remote-sensing applications. There is thus an increasing demand for technology transfer in the form of, e.g., training of both development aid personnel and personnel from developing countries.

For this purpose an International Remote Sensing Institute has been established at Kiruna. The Institute, which is now operating in its initial phase, will offer practical applications courses for a duration of up to six weeks. The courses will be based on the resources of various organizations, among them university institutes, SSC Satellitbild and the Swedish Land Survey in the area. The target groups are primarily development aid personnel and personnel from developing countries.

The Institute was involved in the five-week United Nations training course on remote-sensing education for educators, which was conducted in Sweden in 1990 and was hosted by the Swedish Government. Two weeks of the course were devoted to practical training at the Institute.
